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JOURNAL
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Volume 62 December, 1946 No. 2

PROCEEDINGS OF THE FORTY-THIRD ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

NORTH CAROLINA STATE COLLEGE OF THE UNIVERSITY OF NORTH CAROLINA, RALEIGH, N. C.

After a postponement of the annual meeting of the North Carolina Academy of Science for two years (1944, 1945) because of difficulties in transportation and housing facilities during the war, the forty-third annual meeting was held at North Carolina State College, May 3 and 4, 1946.

The Academy convened in a general session at 10:30 a.m. the first day, President Milton L. Braun presiding. After presentation of five papers of general interest, the session adjourned for lunch at 12:30.

Simultaneously the section of Biochemistry and Physiology met and seven papers were presented.

The second general session was called to order at 2:00 p.m. the same day. After the reading of three papers the session closed and was followed by the business meeting.

The minutes of the last meeting (1943) were approved as published in the Journal of the Elisha Mitchell Scientific Society **59:** 91–128, 1943. Reports of the various committees were then presented as follows:

REPORT OF THE EXECUTIVE COMMITEE

The Executive Committee met in Greensboro, N. C., April 19, 1946. At this meeting the following matters were transacted:

1. A recommendation by Murray F. Buell, Chairman of the High School Committee, that the second and third prizes of the Academy awards be raised from $3.00 and $2.00 to $10.00 and $5.00 respectively was approved.
2. A recommendation also by Dr. Buell that the lantern slide sets owned by the Academy and loaned to schools be transferred to the Extension Department of the University of North Carolina was referred to the Secretary and the various donors with power to act.
3. In a report on "The status of the Academy", the Secretary-Treasurer pointed out that the treasury was dwindling at an alarming rate owing to the absence of many members in service and to the difficulty of collecting dues when no meetings are held.

4. The following were elected to membership in the academy:

Etchells, John L., N. C. State College.
Hamilton, John, Asheville School.
Hansgirg, Fritz J., Black Mountain College.
Lynn, Joseph T., N. C. State College.
Parks, Mabel, Greensboro College.
West, Gladys, N. C. State College.
Williams, Ruby, Reidsville High School.
Yarbrough, John A., Meredith College.

5. The following high school science clubs were reported to have become affiliated with the Academy:

Aycock High School Science Club, Henderson.
Lattimore High School Science Club, Shelby.
Matt Thompson High School Science Club, Statesville.
Needham Broughton High School Science Club, Raleigh.
Rock Ridge High School Science Club, Wilson.
Wheat Swamp High School Science Club, La Grange.

6. The possibility of holding a meeting in 1946 was considered.

REPORT OF THE TREASURER

Below is a statement of accounts as found after the death of the former Treasurer, Bert Cunningham.

STATEMENT OF ACCOUNTS OF THE NORTH CAROLINA ACADEMY OF SCIENCE as of November 1, 1943

Checking Account (The Fidelity Bank, W.D.B.)

Balance June 1, 1943	$145.79
Deposits	119.50
	265.29
Expenditures	161.10
Balance as of November 1, 1943	104.19

Savings Account (The Fidelity Bank, W.D.B.)

Balance as of April 1, 1943	$208.35
Interest, July 1, 1943	1.03
Interest, Nov. 1, 1943	.52
Balance	209.90

The United States Savings Bonds of Defense Series F, maturity value $300.00 are deposited for safe keeping with Mr. C. B. Markham, Treasurer Duke University.

(Signed) H. L. BLOMQUIST, *Treas.*

AUDITORS' REPORT

On the 11th day of November, 1943, we examined these accounts and found them correct.

(Signed) WILLARD BERRY
IRVING E. GRAY
PAUL J. KRAMER, *Chairman*

Another meeting of the Executive Committee was held in Raleigh on May 2, 1946. At this meeting the following matters were transacted:

1. A motion that the policy of paying the Elisha Mitchell Scientific Society $300.00 per year in support of publication of the Journal be resumed in 1946 was passed.
2. A motion was also passed authorizing the treasurer to pay the Elisha Mitchell Scientific Society $150.00 for 1945 (if the treasury could stand it); and that a committee be appointed to confer with representatives of the Society and work out a satisfactory settlement of the Academy's indebtedness for the years 1944 and 1945.
3. It was also recommended by the Committee that all members of the Academy who were not officially in the armed forces and have received the Journal be requested by the Treasurer to pay any delinquent dues since 1943 in order to be considered members in good standing.
4. The Committee authorized the establishment of a new section entitled Clinical Psychology.
5. The Treasurer was authorized to pay all outstanding bills for operating expenses.
6. The Treasurer was authorized to submit his financial statement as of July 1, 1946, to the Auditing Committee.
7. The following were elected to membership in the Academy:

Ansbacher, Heinz L., Duke University.
Bault, Roger Q., Davidson College.
Brannock, Ned F., Elon College.
Caldwell, Ellen R., Eastern Carolina Teachers College.
Caughey, Mary G., Eastern Carolina Teachers College.
Coble, Albert V., Elon College.
Cole, Evelyn, Duke University.
Ellis, Don E., N. C. State College.
Hart, Dennis, N. C. Div. of Game and Inland Fisheries.
Hiatt, Edwin P., U. N. C.
Houle, Egbert F., N. C. State College.
Huneycutt, M. B., U. N. C.
Killian, Carl D., Western Carolina Teachers College.
Lynn, Joseph T., N. C. State College.
Marek, J. W., N. C. State College.
Ferguson, John H., U. N. C.
Horn, Edward C., Duke University.
Morgan, John W., N. C. State College.
Mullis, Iral B., N. C. State College.

Ott, Charles N., Guilford College.
Parker, Helen M., U. N. C.
Rabb, Joe C., N. C. Dept. of Conservation and Development.
Radford, Albert, U. N. C.
Reid, James W., Davidson College.
Ryland, Alice G., U. N. C.
Seeley, J. Frank, N. C. State College.
Stewart, Mary J., U. N. C.
The Sam T. Weyman Memorial Laboratory, Highlands.
Van Horn, Earl C., T. V. A., Murphy, N. C.
Whitwer, E. Eloise, Meredith College.
Ziegler, A. W., U. N. C.

8. Thirty-five former members were reinstated.
9. The Secretary reported the following losses of members:

1. By resignation, 5.
2. By non-payment of dues, 12.
3. By death, the following:
   Arbuckle, H. B., Davidson College.
   Barber, Lena, Raleigh, N. C.
   Brimley, H. H., N. C. State Museum.
   Cunningham, Bert, Duke University.
   Hood, Frazer, Davidson College.
   Kilgore, B. W., N. C. State College.
   Rosenau, Milton J., U. N. C.
   Willoughby, J. W., Wilmington, N. C.

10. The Committee accepted the invitation from Dr. O. C. Bradbury to meet at Wake Forest College in 1947.

The reports of the Executive Committee were adopted.

TREASURER'S REPORT

Financial Statement as of July 1, 1946

Summary

Receipts	
Bank balance (checking acc't), Nov. 1, 1943	$104.19
Gifts	
Ornithological Essay Prize, 1945	20.00
Ornithological Essay Prize, 1946	20.00
For Academy Award Prizes (anonymous)	5.00
Sale of stamps	.50
Refund for personal check (H. L. B.) charged by mistake	10.00
Chemistry Section's share of cost of programs	5.00
Initiation fees and dues (1943, 1944, 1945, 1946, 1947)	1,101.00
Total	$1,265.69
Expenditures	
Stamps	23.00
Stationery	101.02
Subscriptions for magazines for high school science clubs	15.00

Refund on dues	6.50
Error in charging personal check (H. L. B.)	10.00
Returned check for lack of funds	2.00
Prizes	
Ornithological Essays (1944, 1945, 1946)	60.00
Academy Awards (1944, 1945, 1946)	95.00
Secretarial aid (1943–1946)	51.00
Telegrams	1.13
Telephoning	4.37
Elisha Mitchell Scientific Society	600.00
Research Grant (to M. E. Buell)	100.00
Secretarial Commission (10% of dues)	109.50
Programs	29.50
Bank taxes (service, etc.)	11.41
Total	$1,219.43
Bank balance	46.26
	$1,265.69

Savings Account

Fidelity Bank (West Durham Branch)

Balance, Oct. 1, 1943	$209.90
Interest, 4/1/45	3.15
Interest, 1/1/46	2.12
Interest, 10/1/46	1.07
	$216.24
Tax	.48
Balance, Oct. 1, 1946	$215.76

Total Assets

Checking account	$46.26
Savings account	215.76
U. S. Savings Bonds	300.00
Total	$562.02

REPORT OF THE AUDITING COMMITTEE

On the first day of October, 1946, we, the undersigned, have examined this account and found it to be correct.

(Signed) F. G. HALL
H. J. OOSTING
E. T. BROWNE, Chairman

REPORT ON ACADEMY CONFERENCE AT THE CLEVELAND MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (1945)

The meeting convened about 4:00 p.m., Monday, September 11, with over 20 representatives in attendance. The order of business is indicated on the

attached agenda. Those observations which seemed most interesting to your representative are reported briefly.

1. Academy activities:

Dr. E. C. L. Miller of the Virginia Academy reported on the activities of the Virginia Academy, emphasizing their encouragement of research activities and their work with young people. They are increasing their effort to educate the general public on the importance of science by regularly publishing science notes in certain newspapers. It appeared from the discussion that the Virginia Academy is generally regarded as very outstanding among such organizations.

Dr. Miller felt that academies spend too much time on various minor projects. They should, he said, concentrate on major projects. Dr. Caldwell suggested that conservation might constitute such a major project. He believes that erosion and flood control in various river systems present problems on which academies of several adjacent states might cooperate.

Dr. Harlow Shapley, Director of the Harvard Observatory, spoke "as a semi-professional money-raiser" on means by which state academies might obtain outside financial aid. Academies should first have one or two good projects already operating to prove that they are really active. They should then plan another, larger project for which to solicit assistance. State academy projects should preferably deal with state rather than with national problems. It is usually much easier to interest local business men in local problems which will help the community and the state than in problems of general or national interest.

Two academies regularly solicit special contributing memberships from educational institutions and industrial concerns in their states.

2. Research Grants:

Among the questions raised by Dr. Tehon concerning the administration of research grants was one regarding the custody of equipment purchased with special grants. He suggested that such equipment might be regarded as the property of the academy, to be returned for loan to other investigators after the first user was through with it.

3. Junior Academies:

Interest in junior academies and high school science clubs seems to be very high. About 4800 are affiliated with Science Clubs of America. This organization supplies pamphlets, suggestions and material for use by the affiliated clubs. It was suggested that it might be interesting to learn how many students majoring in science have been affiliated with science clubs in high school. One secretary reported that his state has an excellent junior academy, but the senior academy snubs it instead of working with it.

4. Report on publications:

Mimeographed copies of a list of academy publications were distributed and a copy is included with this report. No special recommendations were made.

The chairman was instructed to appoint a nominating committee, and the meeting was then adjourned for dinner.

Following the complimentary dinner given representatives of academies by the A.A.A.S. Dr. Shapley spoke briefly on the importance of local studies on such topics as folklore, dialects, archaeology, history, etc. He believes that the automobile and radio are tending to make people and communities too much alike. Local studies help keep alive knowledge of these interesting differences.

Dr. Watson Davis discussed the activities of Science Clubs of America in supplying material for junior academies and similar groups.

P. J. Kramer

The above report was adopted.

REPORT OF THE RESEARCH GRANTS COMMITTEE (1943–1946)

The North Carolina Academy of Science Research Grants Committee has held no meetings since the Academy meeting in Greensboro in the spring of 1942. During the year 1943 the committee received three applications for the $75.00 grant. After due consideration by correspondence with the members of the committee, the award of $75.00 was made to Mr. William M. Lewis, of North Carolina State College, Raleigh, to help in his studies of the nesting habits of the gray squirrel and the wood duck.

There were no further applications until this spring of 1946, when Dr. Murray F. Buell made application for a grant of $100.00 to enable him to continue the study of peat bogs in the Carolina bays. The committee, now consisting of Dr. C. F. Korstian, Duke University, Prof. J. P. Givler, Woman's College of the University of North Carolina, Dr. W. E. Speas, Wake Forest College, and Dr. J. N. Couch, University of North Carolina at Chapel Hill, after due consideration by correspondence granted Dr. Buell's request and awarded him the $100.

J. P. GIVLER,
C. F. KORSTIAN,
W. E. SPEAS,
J. N. COUCH, *Chairman.*

The report was adopted.

REPORT OF THE POTEAT AWARD COMMITTEE

The Committee on the Poteat Award held a meeting at noon on Saturday and discussed the matter of the most outstanding paper presented at the meeting. Since there were several good papers none of which was especially outstanding over any other, the Committee encountered some difficulty in coming to a unanimous agreement. It was, therefore, decided that no award be granted for 1946.

J. B. DERIEUX
I. E. GRAY
P. J. KRAMER
G. H. SATTERIELD
J. L. STUCKEY
A. D. SHAFTESBURY

REPORT OF THE HIGH SCHOOL SCIENCE COMMITTEE (1944)

The Committee carried on its usual activities. There were a few items added this year that enriched the program somewhat.

There were organized about 54 science clubs in the high schools of the state that the Committee heard about. Most of these are S. C. A. Clubs. Science Clubs of America, Inc. have been a great deal more active this year than last.

Two clubs became affiliated with the Academy this year. We offered the choice of "Nature Magazine," "Fauna," "Natural History," and "Popular Mechanics" again this year.

The inter-club publication which the Academy authorized the Committee to establish, if means could be found, did not materialize this year.

Two years ago the Academy appointed a committee to study the possibility of a Junior Academy. The High School Committee would be interested to know the results of that Committee's discussion. We have been receiving iterature concerning the Virginia Junior Academy and the Illinois Junior Academy. We are not sure that the formation of such an organization in North Carolina would be a wise step for us to take at present although there are some things to be said in favor of it.

No new lantern slide sets were added to the Academy's collection for free distribution this year. Our shipping facilities have been greatly improved by a reconstructed set of shipping boxes. There has been a great deal of demand this year for our lantern slide loans.

The Forestry essay sponsored by the North Carolina Forestry Association was extremely successful. Twenty-seven essays were submitted as compared with 8 last year. These represented many more as some were the result of local contests. In one county, for instance, $40 was raised for $5 prizes to select the 8 best essays to send in to us. The Forestry Association increased their prizes to $20, $10, and $5. We believe that this has been justified by the increased activity this year. First prize went to Robert Gifford of Waynesville, second prize, to Patsy Barnard of Weaverville, and third prize to Margie Poe of Goldston.

The Ornithology essay contest was new this year. Mrs. E. O. Clarkson set up a first prize of $20 and Mr. Harry Davis of the State Museum, second and third prizes: each a copy of "Birds of North Carolina." There were only two entries. First and outstanding was the essay by John Trott of New London and second that by Russell Johnson of Conway. This contest is to be continued next year.

Since the Academy meetings were postponed, the High School Exhibits were held in the State Museum, thanks to Mr. Harry Davis who kindly made space available in the first exhibit room.

Three prizes were offered for projects other than biological exhibits. This is the contest that has been sponsored annually for several years by the Academy. Added to the Academy's first prize of $20 were a second of $3 and a third of $2

contributed to the Academy for the purpose. There were 5 excellent exhibits. The first prize went to Leonard Morgan of Raleigh for his working model of a radio control console. The second prize went to Phyllis Riley of Raleigh for a set of drawings of State Birds. The third prize went to Fowler Morison of Raleigh for his "Study of Human Anatomy."

The Biological Exhibits competition was new this year. Dr. T. E. Powell of the Carolina Biological Supply Company set up three prizes of $20, $15, and $10 for exhibits of preserved biological specimens. There were only 3 exhibits. Horace Loftin, Jr., of Beaufort won first prize with a collection of marine algae. Lacy High of Raleigh won second prize with a plant collection and third prize went to Anna Slack, Nell Rankin, and Betty Peirson all of Raleigh who exhibited an insect collection. Dr. Powell has agreed to continue the contest next year.

The A.A.A.S. Award went to Leonard Morgan of Raleigh and to Margaret Myers of Stocksville. Selection was made on the basis of last year's activity in science in the case of Leonard Morgan. He displayed one of the most outstanding exhibits at last year's contest. Margaret Myers was selected since she is president of this year's most active high school science club in North Carolina.

Recently a member of the Academy wrote suggesting that the Academy do something to extend its encouragement of science to negro schools. The Committee had already looked into that and had discovered means of carrying out a separate program without interfering with the present one should funds become available. The suggestion was made that the Academy might establish a class of dues—"contributing dues" of $5 or $10, the extra proceeds of which could be made available for the use of the High School Committee. Such funds could be used both to make our present program more effective as well as to sponsor a separate program in the negro schools.

The Committee recommends:

1. That the Academy express its appreciation to the North Carolina Forestry Association for its increased participation in the program. We recommend that the Forestry Association be urged to continue sponsoring this project.

2. That the Academy express its appreciation to Mrs. E. O. Clarkson and Mr. Harry Davis for their material assistance in furthering the study of birds in the high schools of the state.

3. That the Academy express its appreciation to Dr. Powell for his material assistance in encouraging the study of biology in North Carolina.

4. That the Academy increase its appropriation for prizes for projects exhibited setting up 3 prizes of $20 as first, $10 as second, and $5 as third. This matter seems rather important to the Committee if we are to continue this competition.

5. That the Academy consider setting up two categories of dues: $2 regular and $5 or $10 contributing dues or something of the sort so that the

proceeds could be utilized by the High School Committee to make its program more effective or increase the scope of its work.

ELIZABETH CONNOR,
W. S. DELOACH,
C. F. DODSON,
J. H. HIGHSMITH,
DOROTHY E. WILSON,
J. S. MEARES,
M. F. BUELL, *Chairman.*

The report was adopted.

REPORT OF THE HIGH SCHOOL SCIENCE COMMITTEE (1945)

[The report of the High School Committee should be read by all members of the Academy. Most of your know we have such a committee but that's as much as most of you know about it. You have perhaps heard that science teaching in our schools is not all it should be but you are probably vague about it. It is your responsibility as a North Carolina scientist and a member of the Academy to know some of the facts.]

This report presents the accomplishments of the past year and attempts to analyze what they mean. It has been a far more successful year than either of the two preceding ones, the time the present chairman has been in office. It is, indeed, very encouraging to have obtained such enthusiastic support from various individuals and organizations with the result of a greatly enlarged program and an appreciable increase in student participation. More students and teachers have taken advantage of what we offer than previously. But that is to be expected since both more time and money have been expended. (In money somewhat over $200.00 or more than four times as much has been spent this year than in 1942–43.) What is remarkable is that there is such a small amount of participation in this science program when the 750 white high schools in the state with their total enrollment are kept in perspective. Looking at it this way, what we have accomplished is very very little. But we must admit, looking at it in this perspective, if we were successful the job would be of such magnitude that we could not possibly handle it. The objective of this committee is to encourage the teaching of science in the high schools. We try to do some of that directly. But actually the real advances have got to be made by the State Department of Education. Not only have we demonstrated through our program that science is being sadly neglected in the high schools of our state but a recent analysis of the National Science Talent Search places North Carolina practically at the bottom. (An abstract of that analysis is given a later paragraph of this report.) The seriousness of this situation in a world where science is increasing in its importance by leaps and bounds cannot be overemphasized.

The program of the committee has not failed for lack of publicity. Publicity was obtained through the wholehearted cooperation of several agencies. In the first place the State Department of Education sent out the complete

program mimeographed in detail together with a letter from Dr. Highsmith urging schools to participate. It went to all the white high schools in the state. The North Carolina Education Association carried a brief note in nearly every issue of "North Carolina Education". The State College News Bureau assisted in getting our material out to the newspapers and radios of the state. Science Clubs of America which circularizes all the high schools in the country listed us in their "Sponsor Guide". Also Science Clubs of America sent us the addresses of all "Clubs" that they organized in North Carolina and we in turn contacted these as soon as we heard about them. Also some of our individual programs got additional attention as will be mentioned below.

Furthermore the committee sent out three issues of a mimeographed news sheet entitled "North Carolina High School Science Notes" to all schools where we were able to discover some sign of interest. These included announcements the committee needed to make together with news of what some of the clubs were doing.

We have become increasingly impressed with the value of science clubs as a means of stimulating interest in science. This year four science clubs became affiliated with the Academy. We cannot be certain how many other active clubs there were. It is surprising more clubs did not affiliate. Affiliation dues are only two dollars and we offer a choice of journals, some of which cost us more than the amount of the dues. It does not seem that there could be many other wide awake clubs in the state.

The committee has decided that the best way to make the A.A.A.S. awards is to base selections on the previous year's accomplishments. On this basis this year's awards went to Phyllis Bowen Riley of Needham Broughton High School, Raleigh, and to Lacy High of Hugh Morson High School, Raleigh. These two were selected as North Carolina's outstanding high school scientists on the basis of their project work last year. It is interesting to note that Phyllis Riley won the first prize in the projects exhibits this year and Lacy High's sister won the first prize in the biological exhibits.

The essay contests reflect the increased cost and energy that went into their administration. The forestry essay contest was indeed, more successful than ever. The North Carolina Forestry Association continued the contest with the three prizes, $20, $10 and $5 as last year. In addition the Association printed a folder including the rules and regulations of the contest and the outline of the winning essays of the past two years. This was distributed to district foresters and local wardens of the State Department of Conservation by Mr. Holmes and Mr. Beichler of the Forestry Division. Thus nearly every school was contacted personally in regard to this contest. Seventy essays were submitted. (The first prize went to Bruce Pate of Wheat Swamp High School, La Grange, the second prize to M. Anne Southerland of South Mills High School, South Mills, and the third prize a tie between Mayola Jessup of Stedman High School, Fayetteville, and Embree Blackard, Jr., of Central High School, Charlotte.)

The ornithology essay contest received a good deal more attention this year than last. Much of the credit for this is due Mrs. J. H. Slaughter of the Raleigh

Bird Club who personally took the responsibility for sending notices including complete information on this contest to all the white high schools in the state. The North Carolina Bird Club printed notices in "Chat". Several bird clubs and individuals sponsored local essay contests. Altogether, thirty-four essays were submitted in contrast to two last year. (The first prize of $20, sponsored by Mrs. E. O. Clarkson of Charlotte, went to Binford Moon of Piedmont Junior High School, Charlotte. The second and third prizes, "Birds of North Carolina", are sponsored by Mr. Harry Davis of the State Museum, Raleigh. The second went to Ines Urdanetta of Central High School, Charlotte, and the third went to Vivian Surles of John Nichols School, Oxford Orphanage, Oxford.)

The circumstances under which the science fair was held this year were unfortunate. In the first place the Academy meetings were postponed because of the O.D.T. ruling on travel. It did not seem wise to cancel the science fair since the students had been urged to plan for it all year. Since the O.D.T. ruling forbade us to invite the students to bring exhibits they were asked to send them to us. Through the kindness of Mr. Harry Davis the fair was held at the State Museum on May 5.

Twenty-two general projects were set up. (The first prize $20 went to Phyllis Bowen Riley of the Needham Broughton High School, Raleigh, for her "Study of Horses"; the second prize $10 went to Jacquelyn Nichols Word of Mills High School, Louisburg, for "A Clay Model of Man's Digestive Tract"; and the third prize $5 went to Harry C. Hall and G. M. Hart of Wheat Swamp School, La Grange, for "Nutrition experiment with rats.")

The biological exhibits contest is sponsored by Dr. T. E. Powell of the Carolina Biological Supply Company who set up three prizes, first $20, second prize $15, and third $5. There were twenty-five such exhibits displayed this year. All three prizes went to students of Hugh Morson High School, Raleigh (the first to Millie High for her "Collection of Sea Shells," the second to Eugene Glenn for a "Collection of Wild Flowers," and the third to Carl Smith for "Collection of Wild Flowers").

Very few of our high schools are interested in obtaining scientists to lecture to student groups. The committee obtained a list of about 90 science lectures offered by members without charge to schools or science groups throughout the state. This list was widely publicized and distributed to the schools. Yet during two years that these lectures have been offered there have been scarcely more than a dozen of them asked for.

A further rather distressing indication of the apathy of a large proportion of our science teachers to take advantage of assistance offered gratis is obvious from the results of the S.C.A. program. Science Clubs of America Inc. has been very active in the last two years. It make an effort to organize science clubs in all high schools throughout the country. There is no cost at all to the science teachers or science groups in the schools. All they need do is to fill in and return a business reply card and then very useful aids come pouring back. Yet with all the advertising and the simplicity of getting the help offered by this organization considerably less than 20% of our North Carolina schools

have taken advantage of it. In addition to this S.C.A. holds a nation wide examination, the "Science Talent Search". The value of such a selective examination has been the subject of some debate. It is as vigorously denounced by some as it is loyally supported by others. Yet regardless of its value, participation in it by the high school students would seem to indicate the degree of enthusiasm and alertness of our science teachers, as well as the concern of our principals and superintendents for science teaching in their schools.

An analysis of the first three years of the "Science Talent Search" was made by H. A. Edgerton, S. A. Britt and Helen M. Davis in a paper entitled *Is your state discovering its science talent*, Science Education, Vol. 28. A portion of this is so pertinent to us that it seems desirable to reprint it here.

"In Wisconsin and North Carolina, each of which had approximately 35,000 high school seniors in 1940, theoretically there should be equal chances in the Science Talent Search. But in Wisconsin there has been a total of 1,402 requests for the three years for entrance materials, and 433 seniors have actually filled out the materials completely; whereas in North Carolina there have been only 758 requests in the entire three years, and only 70 seniors have completed entries. The results are significant: Wisconsin has had 45 Honorable Mentions and 9 trip winners; North Carolina has had only 2 Honorable Mentions and no trip winners."

The committee would like to call attention of the membership to the fact that the Academy at present makes no attempt to encourage science in negro schools.

The foregoing report emphasizes the need for the continuance of this committee. We recommend that all the established programs be continued as far as possible.

We recommend that the Academy extend its appreciation to those who have cooperated in the work of the committee. The names of these individuals and organizations have been mentioned in the body of this report together with the contribution each has made.

We further recommend that this report be called to the attention of the State Department of Education. As a specific suggestion for their consideration we recommend the establishment of state science supervisors. By this we mean at least one or two capable, energetic, enthusiastic, sympathetic persons to travel about visiting and helping the teachers in the laboratories and class rooms. It would represent an extremely small fraction of their total budget and we are convinced it would accomplish much in proportion.

RUBY WILLIAMS,
W. S. DELOACH,
C. F. DODSON,
J. H. HIGHSMITH,
DOROTHY WILSON,
J. S. MEARES,
M. F. BUELL, *Chairman.*

REPORT OF THE HIGH SCHOOL SCIENCE COMMITTEE (1946)

The new Chairman of the High School Science Committee, Dr. A. D. Shaftesbury, made an informal report of the activities of the Committee since the resignation of the former Chairman, Dr. M. F. Buell. The main activity during 1946 has been conducting the contests for the various awards offered by the Academy or under its auspices. The following are the winners of the awards and prizes.

THE ACADEMY AWARD

First prize: Jacqueline Johnson, Hugh Morson High School, Raleigh.
Project: "Birds."
Second prize: Tenth Grade biology class, Hickory High School, Hickory.
Project: Biological models.
Third prize: George Davis, Mills High School, Louisburg.
Project: A model showing sodium and chlorine atoms combining to form salt.

BIOLOGICAL EXHIBITS AWARD

(Carolina Biological Supply Company)

First prize: Millie High, Hugh Morson High School, Raleigh.
Project: "Wild Flowers of North Carolina."
Second prize: James Marshall, Mills High School, Louisburg.
Project: "Construction of a Dog Skeleton."
Third prize: Charles Bass, Mills High School, Louisburg.
Project: "Dissection of Digestive Organs of a Frog."

ORNITHOLOGICAL ESSAY

First prize: Bob Holmes III, Mount Olive High School, Mount Olive.
Subject: "The Bird Population of Wayne County."
Second prize: Martha Witherspoon, Hickory High School, Hickory.
Subject: "The Value of Bird Protection."
Third prize: Sue Boykin, Rock Ridge High School, Wilson.
Subject: "The Eastern Cardinal."

FORESTRY ESSAY AWARD

The awards for the winners of the Forestry Essay contest will be announced at a later date.

REPORT OF LEGISLATIVE COMMITTEE (1945, 1946)

Your Legislative Committee again wishes to call your attention to one of its recommendations published in December, 1942, which calls upon the membership of the Academy to call to the attention of the committee, in writing, any matters which come under its jurisdiction. We would like to remark that the Committee has received no suggestions as regards legislation from any member of the Academy with the exception of the President.

Work of the committee since its last report is as follows: Prior to the meeting of the last General Assembly the chairman made several calls on and had several interviews with Gov. John M. Broughton with the idea of endeavoring to get financial support from the State of North Carolina for the North Carolina Academy of Science. Subsequent to his discussion with the Governor he was asked to appear before the Advisory Budget Commission. Later he appeared before the Budget Commission and finally before an Appropriations Committee of the General Assembly. The Attorney-General's office drew up a bill for presentation to the Assembly. A copy of the bill is in the files of the secretary of the Academy.

The endeavors of the committee along these lines did not meet with success but we have been informed by the Durham representatives to the General Assembly that they are interested in support for the Academy and that if we employ a different technique at the coming meeting of the General Assembly we will be in a better position to obtain funds for the support of the Academy.

Following the adjournment of the Legislature there was little work for the committee to do with the possible exception of looking into the matter of high school science in connection with the science scholarships offered by a national foundation. That was referred to the high school science committee with no action taken by the Legislative Committee.

With the cessation of hostilities the question of control of atomic energy came up and the Legislative Committee, meeting by correspondence, and with the authority of the last meeting of the Academy, when we were given power to act between meetings of the Academy, advised the Atomic Bomb Committee of the United States Congress and the North Carolina delegation in Congress that the Academy supported the civilian control of atomic energy or the McMahon Bill which was then before the United States Congress. The committee received in most cases letters of response from the North Carolina delegation which were in accordance with our support of the McMahon Bill.

The chairman of the committee wishes to express his appreciation and thanks to the other members of the committee for their interest and care in support of the interests of the Academy.

Respectfully submitted:
B. C. BURGESS
B. W. WELLS
HERBERT PRYTHERCH
E. WILLARD BERRY, *Chairman*

The report was adopted.

CONSERVATION COMMITTEE

The Committee on Conservation did not present a formal report. In lieu of this the Secretary takes the liberty of quoting a paragraph from a letter by the Committee's Chairman, J. S. Holmes, to Dr. Milton L. Braun, President of the Academy, dated April 17, 1945.

"I have no definite problem to place before the Academy but it has occurred

to me that scientists and nature lovers should give careful attention to the very serious decline in the species of birds, animals and marine fauna which might be considered commercial species. I have in mind especially the birds which are considered game birds. The very general idea that game birds exist for the sportsman should be combatted by all reasonable people. The threat to these birds was well illustrated by the fortunately unsuccessful attempt to place wild life protection, so-called, under a board of so-called sportsmen, taking it from an existing board of men with more varied interests. I think this Academy together with bird clubs and similar organizations should emphasize their interest in wild life, not for the love of killing but for the pleasure and interest in the life and beauty of the live birds."

The following memorial reports were presented at this meeting:

BERT CUNNINGHAM

In the passing of Dr. Bert Cunningham, the Academy lost its Secretary-Treasurer and its most active member. He died unexpectedly in his sleep at his home between 4 and 6 p.m. on November 27, 1943. During the day he had been at the university as usual. Returning home about 4 p.m., he went up to his room to take a short rest—a rest which became eternal.

Bert Cunningham was born June 3, 1883, in McLeon County, Illinois, the youngest of four children of Parker Dresser and Susie Hammond Cunningham. He attended Saybrook High School for two years but completed his preparatory education in the Academy of Illinois Wesleyan University. He continued his education in Illinois Wesleyan from which he graduated with the B.S. degree. He entered graduate studies in the same institution and obtained the M.S. degree.

After completion of his studies at Illinois Wesleyan, he taught for two years at Missouri Wesleyan.

On October 7, 1907, he married Miss Jean Knapton of Bloomington, Illinois, who survives him. Mrs. Cunningham is one of Durham's best known and most accomplished musicians. Other survivors of his family are a sister-in-law, Helen Knapton, who has lived with the Cunninghams since childhood and two brothers, Wallace and Arthur.

In 1910 he attended the University of Virginia and while there met Mr. W. D. Carmichael of Durham (now of Chapel Hill), who was then principal of the Durham High School. Mr. Carmichael influenced him to consider coming to Durham, and in 1911 he became chairman of the Science Department of the Durham High School.

While engaged in teaching in Durham, Bert Cunningham soon became associated with the late Dr. J. J. Wolfe of Trinity College who inspired and encouraged him to do investigational work in biology. In 1916 he received the M.A. degree from Trinity College and accepted an instructorship in biology in this institution. Wishing to obtain further training he attended the University of Wisconsin from which he received the Ph.D. degree in zoology in 1920.

Returning to Trinity College the same year he was appointed professor of biology and chairman of the department, replacing Dr. Wolfe who had died during his absence.

Bert Cunningham was a popular member of the Trinity College and Duke University faculties. He served as president of the Faculty Club for one year and for more than twenty years was chairman of the schedule committee.

As a scientist Dr. Cunningham was a tireless worker, often staying in his laboratory from early morning till late at night. His interest centered mainly on fundamental phases of biological problems which ranged from factors affecting incubation of eggs of reptiles and birds to various phases of embryology and endocrinology.

As a teacher he was popular and his classes were always well attended. Although sympathetic with his students, he demanded initiative and independence in their studies. He was well known for his work toward improvement of science courses in high schools and colleges in their relation to general education.

Below is a list of his more important publications.

Cross conjugation in *Spirogyra weberi*. Bot. Gaz. **66:** 272–273. 1918.

Notes on occurrence of *Tintinnus serratus* in Chesapeake Bay. Jour. Elisha Mitchell Sci. Soc. **35:** 12–14. 1919.

(With Carrie Hearn) Some observations upon the reproductive rate of *Euglena tripteris* and *Eudorina*. Jour. Elisha Mitchell Sci. Soc. **40:** 185–188. 1924.

Inheritance of harelip. Jour. Hered. **15:** 370. 1924.

(With J. J. Wolfe et al.) An investigation of the microplankton of Chesapeake Bay. Jour. Elisha Mitchell Sci. Soc. **42:** 25–54. 1926.

Contributions of experimental embryology to the study of germinal organization. Jour. Elisha Mitchell Sci. Soc. **43:** 26–42. 1927.

A two-headed fer-de-lance. Field and stream, December, p. 75. 1932.

Amphicephalous reptiles: animals reputed to have a head at each end of the body. Sci. Monthly **37:** 511–521. 1933.

A study of the effect of a course in high school biology on performance in college biology. School Science and Mathematics **34:** 578–588. 1934.

Do snakes have legs? Sci. Monthly **39:** 467–469. 1934.

Apparatus for studying the effect of increased atmospheric pressure upon the developing hen egg. Science **80:** 99–100. 1934.

The endocrine system. South Atlantic Quart. **34:** 384–393. 1935.

(With E. C. Hester) The effects of endocrines on the developmental rate of flesh flies. Jour. Elisha Mitchell Sci. Soc. **52:** 38–50. 1936.

(With Arnold P. Hurwitz) Water absorption by reptile eggs during incubation. Amer. Nat. **70:** 590–595. 1936.

(With Elizabeth Huane) Further studies on water absorption by reptile eggs. Amer. Nat. **72:** 380–385. 1938.

Axial Bifurcation in Serpents. 112 pp. Duke University Press. 1938.

(With M. W. Woodward and Janis Pridgen) Further studies on incubation of turtle (*Malaclemys centrata* Lat.) eggs. Amer. Nat. **73:** 285–288. 1939.

Effect of temperature upon the developmental rate of the embryo of the diamond back terrapin (*Malaclemys centrata* Lat.). Amer. Nat. **73:** 381–384. 1939.

Embryonic growth rate and sex differentiation. Jour. Elisha Mitchell Sci. Soc. **55:** 314–319. 1939.

(With L. J. Flemister) The effect of increased atmospheric pressure on the allantoic vascular bed and the blood picture of the developing chick. Growth **4:** 63–71. 1940.

(With W. L. Williams) Histological changes in the rat testis following heat treatment. Yale Jour. Biol. and Med. **12:** 309–316. 1940.

At the time of his death he was working on the final revision of a textbook of biology which had been accepted for publication.

Dr. Cunningham joined the North Carolina Academy of Science in 1913, served as Secretary-Treasurer from 1919 to 1927 and as President in 1927. In 1940 he was again elected Secretary-Treasurer which position he held at the time of his death.

He had a sincere interest in the Academy and always served it faithfully and conscientiously. He attended regularly the Academy Conference and in 1939–1940 served as its president. He also served for several years as the Academy's representative to the Council of the A.A.A.S. He was ever active in working for a higher realization of the objectives of the Academy, and in extending its influence throughout the state and nation. We miss him in our ranks.

H. L. BLOMQUIST

HOWARD BELL ARBUCKLE

On July 19, 1945, Davidson College and community suffered great loss in the death of Dr. Howard Bell Arbuckle, Sr., for twenty-five years Professor of Chemistry in Davidson College.

Dr. Arbuckle was born near Lewisburg, W. Va., October 5, 1870, the son of John David Arbuckle and Elizabeth Van Lear Arbuckle. At the age of 15 years he entered Hampden-Sydney College in Virginia from which he was graduated Bachelor of Arts, with first honor, in 1889. Being awarded a fellowship for the following year he returned to Hampden-Sydney and received the Master of Arts degree in 1890. From 1891 to 1894 he was Professor of Ancient Languages in the Seminary West of Suwanee, a foundation connected with the University of Florida. In 1894–1895 he became a special student in chemistry in the University of Virginia and, continuing these studies at the Johns Hopkins University thereafter, received the Doctor of Philosophy degree in Chemistry in 1898. Meanwhile, in 1896, he was married to Miss Ida Meginniss, who remained his faithful companion until her death in 1944. Their two children, Lt. Col. Howard Bell Arbuckle, Jr., and Adele Taylor (Mrs. T. S. Logan), both now residents of Davidson, survive their parents.

Upon completion of his doctorate in 1898 Dr. Arbuckle joined the faculty

of Agnes Scott Institute (later College) in Decatur, Ga., where he rose to the rank of Professor before he left in 1912. In that year be became Professor of Chemistry in Davidson College and served continuously until his retirement in 1937, when he became Professor Emeritus.

In the course of more than forty years in the profession of teaching Dr. Arbuckle became widely recognized by his fellow-laborers. He was a founder and President of the Georgia Section of the American Chemical Society, and later was President of the North Carolina Section; he was President of the North Carolina Academy of Science in 1925; he was for eight years Grand Chancellor of the Honorary Chemical Society, Gamma Sigma Epsilon. He was a member of Phi Beta Kappa and of Omicron Delta Kappa. In the field of scholarly contributions he is remembered for numerous articles in chemical and agricultural journals, for research in corn proteins and cellulose products, and especially for his re-determination of the atomic weight of zinc and cadmium, the findings of which, though made nearly half a century ago, have withstood the tests of more recent scientific investigations.

If his professional colleagues in science will remember Dr. Arbuckle for these academic acomplishments his friends of the college and community will recall more intimate and personal attributes which make him well-remembered and loved. Generations of college men, hearing the name of their former teacher, will remember with gratitude and affection his unfailing interest in them as students and the inspiration he unfailingly supplied in their pursuit of knowledge. He was never too busy to help the puzzled pilgrim; he was never so learned as to discourage the honest seeker after knowledge. This interest, moreover, was evident not only inside the classroom in the formal pursuit of knowledge but in the multitude of student activities on the outside as well. His gracious home welcomed on Sunday evenings many a homesick freshman, and when they left they had somehow been made to know that they had not only been entertained but that the host had himself actually enjoyed the whole affair. To his fraternity, Pi Kappa Alpha, a particular and even more zealous interest was always given. He was not only the guide and councillor of the local chapter throughout his long tenure at Davidson, but also led the national organization as Grand Councillor for twenty years, evincing his customary interest and a genuine ability to understand and direct into constructive channels the organized social life of college groups. And yet a contribution such as this, organized and recognized, was not the most lasting or the most significant service he gave to Davidson College. For he was not a spectacular man. The continuous, quiet service he rendered, unrealized and unrecognized, in the classroom, in the village, in the church, to the sick, to the needy, to the destitute, will long endure.

An unusual versatility was a noticeable characteristic of the man. The intense interest and friendly curiosity that made him so approachable to students also made him active and useful in many other realms of life. The scientific quest for truth, which inspired him in the classroom and the laboratory, led him to seek knowledge of nature in other forms. The physical world about him

challenged his understanding; whether he experimented with bees, sheep, gardens, golf, or with test tubes and formulae, the same deliberate quest for knowledge kept him busy. And so it was also in various other walks of life: the variety of his activities mark him as a dozen men in one; yet there was a unity in his character which made him, if a versatile man, yet a harmonious human multitude.

In this variety of interests and activities one further characteristic needs to be mentioned. Dr. Arbuckle loved people. Not just scientific people, not just educated people, not just white people, but the common herd as well. He was a folksy man and loved to talk with student, farmer, negro, convict, among all of whom he labored with whole-hearted intensity and to whom he gave years of devoted service because he loved them all. For 28 years an elder in the Presbyterian Church, this was his way of translating his religion into action. Even as his Master had commanded he "did it unto many of the least of these." His friendship was freely bestowed in liberal, almost wanton, measure to the unfortunate and the sore distressed, and what measure of comfort, aid, and inspiration he brought them is incalculable. He was a learned man who never lost the common touch.

O. J. THIES
F. W. JOHNSTON

H. H. BRIMLEY

Herbert Hutchinson Brimley was born on March 7, 1861, in the village of Willington, County of Bedford, in the midlands section of England. He died April 4, 1946. His forebears had farmed at Willington for three generations or more, but high rentals and competition with American wheat discouraged the family and they resolved to migrate to Australia or Canada. At this point an immigration agent of the North Carolina Board of Agriculture found the prospects. Result was that the parents with three sons and two daughters arrived in Raleigh in a blizzard on the last day of 1880. The hotel for this night occupied the site where Herb and his brother, Clement, were to make their notable contributions to the zoological sciences of eastern America.

Eight years in the Bedford County School at Elstows, the old home of John Bunyan, constituted Herb Brimley's formal education. He excelled in mathematics, football and swimming. At the end of school he joined an older brother for a clerical job in the Iron Works, but the lure of the out-doors on another continent drew him away from this. At home near the River Ouse spare time forays for collecting birds and eggs had planted the naturalist's seeds.

Near Raleigh the family's attempt at farming the rocky hills was not successful, and Herb fell back on school teaching in a one-room log building on the present Meredith College campus. The salary was $30.00 per month for a three months' term. The English accent and unruly pupils combined to make this an unpleasant vocation. Meantime, he had secured a small book, "Taxidermy Without a Teacher", and this furnished a guiding impulse. With brother Clem, he quickly developed a business of collecting, preparing and

selling zoological specimens. At the time the Carolina field was still a new one and the Brimley brothers sent their handiwork to scientists in far places.

Herb soon had a reputation that caused the State Board of Agriculture and Immigration to seek his services in 1884 to mount specimens for the State Centennial Exposition. Similar responsible work followed for the Chicago Exposition (1892), The Charleston Exposition (1901), the Saint Louis Exposition (1904), the Boston Food Fair (1906), and the Jamestown Exposition (1907).

Meanwhile a vision was nurtured. The Board of Agriculture had a collection in two untidy rooms, and called it a Museum. In the face of many obstacles, Herb Brimley took charge of this in 1895, salary $75.00 per month, and began the enlargement program to accommodate exhibits coming back from expositions. Literally, millions of visitors came from North Carolina and elsewhere to appreciate the exhibits of our Natural History and Natural Resources. For more than sixty years he gave his best to build for his adopted State the leading Museum in this section of America. Being a self-taught scholar, he always cherished worth-while publications and built an excellent Museum Library. In 1941 the Board of Agriculture fittingly designated this as the "Brimley Library of Natural History". Further accessions from friends and others have fixed this as a worthy, useful, and growing collection.

In his long career, Herb Brimley found time for a hearty participation in social, civic, and scientific organizations. He was a founder and life member of the North Carolina Academy of Science, the Raleigh Natural History Club, the Raleigh Bird Club, and the North Carolina Bird Club. He held active memberships in the American Ornithologists Union, the American Society of Mammalogists, the American Association of Museums, the Museums Association of Great Britain and the American Museum of Natural History. In all of these he has had official position and made original scientific contributions on many occasions. With brother Clem and T. Gilbert Pearson, he was author of the volume, "Birds of North Carolina," in both the 1919 and 1942 editions. He was an active collaborator with Hugh M. Smith in preparing the volume "Fishes of North Carolina" in 1907.

As a citizen, he expressed himself in active leadership in his Rotary Club, his Boy Scout district, as head of Raleigh's Festival Association, and always he was foremost among those who would conserve the recreational assets of hunting and fishing for North Carolina. His clean sportsmanship was traditional, and he was always sought out as a genial boon companion. He touched the lives of thousands of young people and they perpetuate his tradition.

HARRY T. DAVIS

BENJAMIN WESLEY KILGORE

Dr. Benjamin Wesley Kilgore, Director of the North Carolina Agricultural Experiment Station from 1901 to 1907, and from 1912 to 1925; Dean of Agriculture at the North Carolina State College from 1923 until 1925; first director of Agricultural Extension in North Carolina from 1914 to 1925, died in Rex Hospital at Raleigh on Monday evening at 7:15 o'clock on December 27, 1943. At the time of his death he was State Chemist, primarily in a consultant capacity.

Dr. Kilgore came to North Carolina in 1889 as a young assistant chemist for the Experiment Station. He had been graduated from the Mississippi State College in 1888 and awarded his Master's degree in 1891, while on a brief return to his native state as State Chemist. He did advanced work for his Doctorate in chemistry at John Hopkins University. He was a native of LaFayette County, Mississippi.

These briefly are the salient facts about the career of a great agricultural leader and scientist who made his contribution to the agricultural advancement of North Carolina and who was respected and honored throughout the South and the Nation for his administrative ability in the field of agricultural education. Dr. Kilgore did much to fashion the pattern by which the agricultural research and extension work in his adopted state would be conducted. Largely because of that early pattern, North Carolina began to move steadily forward as a great farming state.

His record in promoting cooperatives among farm people is well known, since he was largely responsible for the first great cooperative movement among North Carolina farmers. He had the ability to command the utmost from those who worked with him in the field of agricultural education. He continually sought to make working conditions favorable for those serving with him in the Experiment Station and Extension Service and he encouraged initiative and progressive thinking among the younger members of the two staffs. He was known as a business man of sound judgment, a deep thinker, and a successful leader of men.

Withal, however, he was a reserved person, inclined almost to shyness, seeking no personal prestige at any time but preferring to remain in the background where he helped to fashion methods, policies and plans which would blossom forth into surprisingly valuable contributions to the rural life of the state. He early saw the need for coordinated research throughout the South and was one of the founders of the Association of Southern Agricultural Workers. He served as its secretary from 1889 until 1911, guiding the organization through its formative years.

Great honors were heaped upon his frail shoulders through the years. Davidson College and North Carolina State College both gave him honorary degrees of Doctor of Science. The Association of Southern Agricultural Workers presented him with a plaque for his service to southern agriculture. The National Farm Bureau, The North Carolina State Grange, and other societies, fraternities, and organizations placed upon him the accolade of their approval for his efforts to build better rural life in the state and nation.

To the end he was the scientist and thinker. Those close to him, knew of his great personal charm. He was never strong or robust in a physical sense but by conserving his strength as the years advanced, he continued to carry heavy responsibilities and burdens until he became known as one of the South's greatest agricultural scientists and leaders.

F. H. JETER

MILTON J. ROSENAU

(See Proceedings of the Mitchell Society)

FRAZER HOOD

Dr. Frazer Hood, prominent member of the Davidson College faculty and a southern educational leader, died in Charlotte, on June 19, following a long illness.

The son of the late Captain Charles B. Hood and Mary Wiley Hood, Dr. Hood was born in Tupelo, Miss., on June 2, 1875. He attended Southwestern University in Clarksville, Tenn., from 1892 to 1896, receiving the A.B. degree. While a student, he was College Orator and Salutatorian. He was a member of Phi Delta Kappa, the Kappa Alpha social fraternity; and Sigma Upsilon, national literary fraternity. After graduating from Southwestern, Dr. Hood attended the University of Mississippi and Johns Hopkins University. Winning a Fellowship, he attended Yale and received the Ph.D. degree in 1903. His thesis took first honor. In 1903 he married Kalista Wagner of Water Valley, Miss. Dr. Hood first taught at Hanover College in Indiana; at the University of Oklahoma; and at West Tennessee Teachers' College. During World War I he was a first lieutenant on the Army Psychology Examining Board. In 1920 he came to Davidson as Professor of Psychology from Northwestern University, Illinois. During summer sessions he taught at North Carolina State College, the University of North Carolina, and at Ohio State University. He was president of the North Carolina College Conference in 1933-1934.

The same year, Dr. Hood was president of the Board of Trustees of Lees-McRea College at Banner Elk, N. C. He was president of the Educational Association of the Southern Presbyterian Church in 1942–1943. He was author of "Every Man's Insurance," "The Duties and Responsibilities of College Trustees," and numerous psychological articles. He was a popular lecturer in the field of psychology and religion.

Surviving are his widow, one daughter, Kalista, and one sister, Mrs. R. E. Harrison of Germantown, Tenn.

JOHN L. PAYNE.

All of the above reports were adopted with a rising vote.

REPORT OF THE NOMINATING COMMITTEE

The Nominating Committee submitted the following nominations:

President: John N. Couch, U. N. C.

Vice-President: Ruth M. Addoms, Duke.

Secretary-Treasurer (3 years): F. H. McCutcheon, N. C. State.

Member of the Executive Committee: F. G. Hall, Duke.

Member Research Grants Committee: O. C. Bradbury, Wake Forest.

There being no nominations from the floor, the Secretary was asked to cast the ballot and declare the nominees elected. This concluded the business and the meeting was adjourned.

After the business meeting several well organized tours were made to different places of interest on the campus of State College. The results of these tours was an impression of a rapid development of technical education in North Carolina.

At 6:30 p.m. the Academy members enjoyed a complimentary picnic supper of fried chicken, which because of rain, was held in the Gymnasium instead of in Pullen Park as planned.

The evening meeting was held in the Y. M. C. A. Building, Dr. Mary E. Yarbrough, Vice-President of the Academy, presiding. After announcing the winners of the various prizes and awards she introduced Chancellor Harrelson of State College who welcomed the Academy. This was followed by the Presidential Address by Dr. Milton L. Braun of Catawba College. Speaking on the subject of "Rubber under tension or the misbehavior of stretched rubber", Dr. Braun held the interest of his audience by his spontaneous humor and his simple treatment of a highly technical subject.

Following the Presidential Address was a social hour at which the wives of the Faculty of State College acted as hostesses.

Most of the sectional meetings were scheduled for Saturday forenoon. These were well attended. Many good papers were presented which provoked considerable discussion. The new section, Clinical Psychology, met with the Psychology Section. The following officers were elected for the respective sections:

Biochemistry and Physiology: Chairman, G. H. Satterfield; Secretary, Mary E. Yarbrough.

Botany: Chairman, D. B. Anderson; Secretary, E. C. Cocke.

Geology: Chairman, B. N. Moneymaker; Secretary, E. W. Berry.

Mathematics: No meeting.

Physics: No meeting.

Psychology: Chairman, Donald K. Addoms; Secretary, William McGehee.

Clinical Psychology: Chairman (to be appointed); Secretary, Marion Stanland.

Wild Life: Chairman, John D. Findlay; Secretary, Ross O. Stevens.

Zoology: Chairman, B. B. Brandt; Secretary, I. E. Gray.

The following constitute the personnel of the standing committees:

Executive: J. N. Couch, Ruth Addoms, F. H. McCutcheon, D. B. Anderson, O. J. Thies, and F. G. Hall.

Research Grants: J. P. Givler, Chairman (1947), E. W. Berry (1947), W. E. Speas (1948), O. C. Bradbury (1949).

Special committees

Auditing: E. T. Browne, H. J. Oosting, F. G. Hall.

Conservation: J. S. Holmes, C. H. Bostian, C. F. Korstian, and R. A. Lineberry.

High School: A. D. Shaftesbury, Ruby Williams, C. F. Dodson, J. H. Highsmith, Dorothy E. Wilson, and J. S. Meares.

Legislative: E. W. Berry, B. C. Burgess, H. F. Prytherch, and B. W. Wells.

Nominating: H. F. Prytherch, C. M. Heck, and W. F. Prouty.

Necrology: A. L. Hook, W. E. Jordan, Z. P. Metcalf, and F. Louise Schaeffer.
Poteat Award: A. D. Shaftesbury, J. B. Bullitt, J. B. Derieux, I. E. Gray, P. J. Kramer, J. W. Lasley, Jr., G. H. Satterfield, and J. L. Stuckey.
Resolutions: O. Stuhlman, Jr., K. L. Barkley, and W. D. Mankin.
Secretarial and Constitutional: H. R. Totten, H. L. Blomquist (third member to be appointed).

Approximately 250 members and visitors registered during the meetings. The following papers were presented during the meeting. Those marked with an x are abstracted in these proceedings.

GENERAL SESSIONS

Address of Welcome. J. W. HARRELSON, Chancellor, North Carolina State College.
Presidential Address. Rubber under tension, or the misbehavior of stretched rubber. MILTON L. BRAUN, President of the Academy.
x*Investigation on the effect of "red heart" in pond pine with reference to pulp wood.* E. E. RANDOLPH AND JULIAN HOFMAN, N. C. State.
Notes on Venus flytrap (Dionaea muscipula). L. A. WHITFORD, N. C. State.
x*A thin sheet of asbestos increases heat loss.* J. B. DERIEUX, N. C. State.
North Carolina Resource-Use Education Commission. FELIX A. GRISETTE, N. C. State Planning Board.
On the irreducibility of certain classes of polynomials. ALFRED T. BRAUER AND GERTRUDE EHRLICH, U. N. C.
"Human pick up" by a moving aeroplane (moving picture). F. G. HALL, Duke Medical School.
The North Carolina Wild Life Federation and its major objectives. Ross O. STEVENS, N. C. Wild Life Federation.
The modulus of elasticity of the internodes of the giant reed (Arundo donax). OTTO STUHLMAN, U. N. C.

BIOCHEMISTRY AND PHYSIOLOGY SECTION

The effect of Vitamin B complex deficiency and quinine on intestinal motility in the rat. G. C. KYKER, MILDRED MCG. HEDGPETH AND VIOLET YOUNG, U. N. C. School of Medicine.
The effect of tryptophane upon nicotinic acid synthesis in the rat. W. A. PERLZWEIG, F. ROSEN AND J. W. HUFF, Duke Medical School.
The enzymatic hydrolysis of phytin. J. C. ANDREWS AND ENRIQUE HERRARTE, U. N. C. School of Medicine.
Cinchona alkaloids and the kidney. E. P. HIATT AND VIRGINIA SUHRIE, U. N. C. School of Medicine.
The activation of purified prothrombin. J. H. FERGUSON, U. N. C. School of Medicine.
Oxygen requirements at high altitude. F. G. HALL, Duke Medical School.

Liver lecithin as related to the choline and cholesterol content in diet. CAMILLO ARTOM AND W. E. CORNATZER, Bowman-Gray School of Medicine.

BOTANY SECTION

A size study of fossil pollen. MURRAY F. BUELL, N. C. State.

x*A stain for ascospores of yeast.* I. V. SHUNK, N. C. State.

x*A collection of marine algae from Brazil.* LOUIS G. WILLIAMS, Duke.

x*Control of Granville (bacterial) wilt on tobacco by soil treatment with urea in combination with corn rotation.* T. E. SMITH, Agric., Oxford.

x*A comparison of photosynthesis in individual pine needles and entire seedlings at various light intensities.* PAUL J. KRAMER AND WALTER S. CLARK, Duke.

Some noteworthy marine algae new to Beaufort, N. C. H. L. BLOMQUIST AND H. J. HUMM, Duke Marine Laboratory.

Nutritional studies of a cellulose-destroying chytrid. JOSEPHINE STEWART, U. N. C.

Periodicity in discharge of oospheres of Sargassum filipendula. H. L. BLOMQUIST, Duke.

Studies in the nutrition of some aquatic myxomycetes. HELEN PARKER, U. N. C.

Gel extracted from the red alga Hypnea musciformis. H. J. HUMM, Duke Marine Laboratory.

Some fungi parasitic on mosquitoes. J. N. COUCH, U. N. C.

GEOLOGY SECTION

x*The origin of North Carolina vermiculite.* T. G. MURDOCK, N. C. Dept. of Conservation and Development.

x*Two peneplains under the Coastal Plain.* W. F. PROUTY, U. N. C.

Geology of two great dams in western North Carolina. B. C. MONEYMAKER, Knoxville, Tenn.

x*Upper Devonian bioherms in central Arizona.* JOHN W. HUDDLE, U. N. C.

Development in the mineral industry in North Carolina. J. L. STUCKEY, N. C. State.

x*Copper in the midland counties of North Carolina.* E. W. BERRY, Duke.

PSYCHOLOGY SECTION

A comparison of findings on the Wechsler and Stanford-Binet examinations. M. J. WHITE, U. N. C.

A study of the precision of perception of certain apacial relationships. FRANCES SCHULZE AND KARL ZENER, Duke.

Effect of exposure time and fixation point on the perception of grouped digits. JAMES C. DIXON, U. N. C.

A quantitative approach to early childhood recollections. HEINZ ANSBACHER, Duke.

Adaptation in energy mobilization: changes in general level Palmal skin conductance. ELIZABETH DUFFY, Woman's College, U. N. C., and O. L. Lacey, U. of Alabama.

A case of fatigue-induced monocular diplopia. JOHN F. DASHIEL, U. N. C.
The effect of weak intensities of hunger on the behavior mediated by habit of maximum strength. I. J. SALTZMAN AND SIGMUND KOCH, Duke.
Revision in rating scale technique. ROBERT J. WHERRY, U. N. C.

CLINICAL PSYCHOLOGY SECTION

Some case studies in reading. C. D. KILLIAN, W. C. T. C.
Some vagaries in mental tests of subnormal individuals. ELIZABETH M. BROWN, Caswell Training School.
The problem of the returning dishonorably discharged veteran. RALPH T. HINTON, JR., State Board of Public Welfare.

WILD LIFE SECTION

A vegetative study of Holly Shelter Wildlife Refuge. B. W. WELLS, N. C. State.
Rearing marine mullet in fresh water ponds. H. F. PRYTHERCH, U. S. Bureau of Fisheries.
Deer trapping. FRED MAHAN.
Norris Lake and year around fishing. R. W. ESCHMEYER.

ZOOLOGY SECTION

x*Development of the guinea pig ovary from sexual differentiation to maturity.* C. G. BOOKOUT, Duke.
x*The Metazoa parasitic in cotton rats of Wake County.* REINARD HARKEMA, N. C. State.
x*Litter and soil animals of the Duke Forest.* A. S. PEARSE, Duke.
North River experimental oyster farm. H. F. PRYTHERCH, U. S. Bureau of Fisheries.
Items from the life history of the queen snake (Natrix septemvittata). E. E. BROWN, Davidson.
A refractory case of visceral Leishmaniasis. REINARD HARKEMA, N. C. State.

NORTH CAROLINA SECTION OF THE AMERICAN CHEMICAL SOCIETY

The conversion of alpha-amino acids to oxazoles. H. WILEY, U. N. C.
x*An automatic valve for the measured delivery of liquids.* L. B. RHODES, Dept. of Agric., Raleigh.
Isolation of a ketone in an aromatic cyclodehydration of the glycol ether type. CHARLES K. BRADSHER AND LEONARD J. WISSON, Duke.
Some peculiar properties of liquid argon. OSCAR K. RICE, U. N. C.
Electrophoretic analysis of protein in serum. E. R. COOPER, Duke Medical School.
Some basically substituted derivatives of quinazoline. R. L. MCKEE, M. K. MCKEE AND R. W. BOST, U. N. C.
The recognition of field crops of North Carolina as authoritative chemists. IVAN E. MILES, Dept. of Agric., Raleigh.

Abstracts:

Investigation on the Effect of "Red Heart" in Pond Pine with Reference to Pulp Wood. E. E. RANDOLPH and J. G. HOFMANN.

In the coastal plain of North Carolina, South Carolina, and Virginia are hundreds of thousands of acres of pond pines (*Pinus serotina*). These are almost pure stands particularly in the pocosins and in the low poorly drained areas. These trees have always been of average economic value, but since the increase of pulp mills in the coastal areas pond pine has become one of the main sources of pulp wood. There are two reasons for its suitability for this use. It grows in the low wet land better than other pines do and also it withstands severe repeated fires better than other trees. The same fire which kills other species of pines kills only the terminal shoots of the pond pine.

Although these pines survive destructive fires the fire scars make the trees susceptible to disease. The principal disease which affects pond pine is "red heart". This is a fungus disease (*Fomes pini*) which attacks the heart wood only. It starts usually at the bottom of the tree and works its way up the heart. Often the butt cut in advanced stages of the disease becomes pithy and even hollow while the upper part of the tree is solid. A distinguishing characteristic of the disease is that in the early stages of its progress the heart of the tree turns reddish color even though the wood seems to be perfectly sound.

This disease causes a problem of economic importance. Buyers of pulp wood refuse to buy wood from trees with "red heart" for fear that the quality and quantity of pulp may be reduced. There is no way to tell that a tree is diseased until it is cut. The result is that thousands of trees are cut and left in the woods because there is no market for them for pulp. Lumber men buy the logs if the disease is in the initial stage but pay only fifty per cent of the market value.

The purpose of this investigation is to study the effects on the cellulose by the progress of the disease with reference to the quantity and quality of the pulp produced from affected wood, to determine at what stage of the progress of the disease the wood ceases to be suitable for pulp, and thereby produce additional revenue to the owner and an additional volume for the mills.

Trees were studied microscopically in sections from the bottom to the top. Our study indicates that "red heart" is one of the "white rots" and attacks first the lignified tissue and the other constituents of the wood before it attacks the cellulose. In the early stages of the disease the tree seems to be sound wood interspersed with fungus mycelium but differing from sound wood mainly by its red color. In the advanced stage the wood becomes filled with small pockets apparently with the lignin tissue consumed. The remaining structure of the wood responded to chemical test for cellulose.

Inasmuch as pond pine is an important source of pulp wood we undertook to determine the volume per cent, the weight per cent, and the quality of the pulp obtained from sections of trees at different stages of infection. A one cubic foot digester was used to cook the chips. The regular sulphate process was employed according to standard mill practice. The sheets were prepared

on a standard sheet mold, pressed in a hydraulic press, dried on an electric sheet drier. The test sheets were made uniform to check in a micrometer type standard thickness tester. Strength tests were made on a Mullen bursting strength tester and on an Elmendorf Tear Tester. Comparative tests were made on sound wood chips, on "red heart" chips of different degrees of infection, on mixtures of varying percentages of sound wood and infected wood.

The next step will be to duplicate the work on pilot size scale and on full scale production in the mill under regular mill operation conditions. The study indicates that:

First, "Red heart" attacks first the lignin, resin, and other constituents of the wood before it attacks the cellulose, in other words it seems to do the same thing as the chemical method of cooking does;

Second, Up to a certain stage the weight and volume per cent is appreciably affected;

Third, The strength of the pulp up to a certain advancement of the disease compares favorably with pulp from unattacked trees.

A Thin Sheet of Asbestos Increases Heat Loss. J. B. DERIEUX.

Hot air pipes of tin when installed in a residence are usually coated with a thin sheet of asbestos insulation. It was observed that basements which contain such pipes get unduly warm, as though the insulation is not very effective. An investigation of it was made by comparing the rates of heat loss of a bare tin can and an identical one covered with a thin sheet of asbestos when they were filled with boiling water. It was found that the coated one lost heat much more rapidly. Two layers reduced it, but it required seven layers, about one-fourth of an inch, to reduce the rate to that of the uncoated one. The conclusion is that a thin sheet of asbestos increases heat loss from tin hot air pipes, and, therefore, should be left off entirely.

The reason for this is that there are three sources of heat loss: (1) conduction; (2) convection; (3) radiation. As to the first source, asbestos is a poor conductor and, therefore, a thin sheet reduces the rate of heat loss by conduction through the pipe walls by a small amount. In regard to the second source, the loss by convection, being due to the circulation of the air surrounding the pipe, is only very slightly affected by the asbestos. The third source of radiation is the one that makes the great difference. Radiation loss is greater on rough, dull surfaces, least on bright smooth surfaces. Therefore, the rough dull asbestos surface gives a much greater rate of heat loss by radiation than the bright polished tin. This latter source predominates and, therefore, the net result is an increase in the heat loss produced by a thin sheet of asbestos.

A Stain for Ascospores of Yeast. IVAN V. SHUNK.

Add a bit of yeast culture containing asci and ascospores to a small drop of water on a microscope slide. Spread and allow to air dry. Then add a few drops of Methylene blue stain (Methylene blue 0.3 gram dissolved in 30 ml. of 95% alcohol and 100 ml. of water added) and let stain act for 10 minutes or longer.

Wash off the excess stain by dipping in a beaker of water or by gentle washing under the tap and allow the slide to drain and dry.

Then add, with a wire loop (inside diameter of loop about 2 mm.), a loopful of nigrosin solution (prepared by dissolving 1½–2 grams of water soluble nigrosin in 100 ml. of water and then adding 10 drops of formalin).

Spread the loopful of nigrosin as uniformly as possible to cover an area of the smear of about 2 sq. cm. Allow to dry and mount in balsam or diaphane. The ascospores appear deep blue and the ascus is outlined by the nigrosin staining the glass to a slight extent.

A Collection of Marine Algae from Brazil. LOUIS G. WILLIAMS.

While stationed with various Naval Air Facilities in Brazil during parts of 1944 and 1945 collections of littoral marine algae were made from the sandstone reef south of Recife, Pernambuco, and from the island of Fernando Noronha, which lies about 250 miles northeast of the Brazilian bulge. Approximately 110 species and varieties have been identified, which show strong affinities with the algae of the West Indies and Florida. Several of them have not been previously reported from Brazil. Many of them have not been previously reported from the general locality in which they were collected. A few are new to the South Atlantic Ocean, and one is new to the Atlantic Ocean.

Control of Granville (Bacterial) Wilt on Tobacco by Soil Treatment with Urea in Combination with a Corn Rotation. T. E. SMITH.

Wilt (*Bacterium solanacearum* E. F. S.) on tobacco and other plants was controlled by treatment with urea but tobacco grown the summer after treatment was worthless commercially because of the excessive nitrogen persisting in the soil. However, tobacco of good quality was produced on urea-treated soil by growth of tobacco in rotation with 1 year of corn in small plot trials completed in 1941. This experiment was repeated in 1943 in trials at 5 locations with a total of 9 replications on sites where wilt killed over 90 per cent of the tobacco in 1941. Urea (Uramon, 42 per cent N) was applied broadcast and disked into the soil at 3 rates in October, 1941, or March, 1942. Corn was grown the summer of 1942. Tobacco was grown in 1943. The 250, 500, and 1000 pound rates per acre of Uramon averaged 63.0, 36.4, and 13.0 per cent wilt respectively on August 1. The tobacco ripened and cured well. In yield and value data taken on plots in triplicate, the 1000 pound rate averaged 977 pounds per acre valued at $39.30 a hundred weight on the 1943 market. Reduction in wilt severity by 1000 pound rate was adequate for commercial use even though the disease was not eradicated. Quality of the cured leaf was satisfactory.

A Comparison of Photosynthesis in Individual Pine Needles and Entire Seedlings at Various Light Intensities. PAUL J. KRAMER and WALTER S. CLARK.

It was found by Kramer and Decker that hardwood seedlings reach their maximum rate of photosynthesis at one-fourth to one-third of full sunlight while pine seedlings attain only about two-thirds of maximum photosynthesis

at that light intensity. Research was started to find why pine seedlings have a low rate of photosynthesis in the shade. It was considered possible that the needles may shade each other more than do leaves of broad leaved species. To test this pine needles were so arranged in small water-cooled chambers that every needle was fully exposed to light and no mutual shading occurred. The seedlings with these chambers attached were placed in an air-conditioned chamber and exposed to light intensities ranging from deep shade to full sun. The individual pine needles behaved like hardwood seedlings, attaining maximum photosynthesis at about one-third of full sunlight. It is concluded from these data that the principal reason for the low rate of photosynthesis of pine seedlings in the shade is the shading of the needles by one another.

The Origin of North Carolina Vermiculite. T. G. MURDOCK.

Field and laboratory investigations of the North Carolina vermiculite deposits, which occur with peridotites and pyroxenites, as selvage veins along the contact and in zones of weakness in the interior of the basic formation, indicate that such deposits, contrary to a general acceptance by the literature, are not hydrated magnesium silicates formed by the hydrothermal alteration of biotite or phlogopite mica. It seems more logical to believe that hot solutions derived from the cooling basic magma and later intruded pegmatite solutions flowed along joints and fractures in the dunites and pyroxenites. At favorable points the solutions attacked and replaced these rocks with chlorite, which was in turn hydrated by circulating meteoric water. This belief is substantiated by the occurrence of vermiculite pseudomorphs after pyroxene and chlinochlore, by hand specimens of chlorite partly hydrated to vermiculite, by the occurrence of fresh chlorite in the bottom of deeper workings, and a general similarity of vermiculite to chlorite in chemical composition. A vermiculite-like material which is clearly a hydrated or weathered biotite is sometimes found. Such occurrences, however, are entirely unassociated with the ultrabasic rocks, and the material exhibits few of the characteristics of a true vermiculite, either upon a visual examination or after exfoliation tests. The statement that "the term 'vermiculite' is applied to a group of foliated minerals that generally are alteration products of biotite, phlogopite, and other varieties of mica'" is open to question, at least when the North Carolina deposits are concerned.

Two Peneplains under the Coastal Plain. W. F. PROUTY.

Very little has been known about the floor of the coastal plain of North Carolina until very recently. Up to the time of the drilling of the Havelock well near New Bern, only six wells have been drilled to the basement rocks in North Carolina and four of these were comparatively shallow wells, nearer the fall-line than the coast. Early in 1934 a magnetometer survey was run by members of the Department of Geology, University of North Carolina, from Myrtle Beach to a few miles west of Florence, South Carolina. This survey showed that the highly magnetic rocks of the coastal plain floor shallowed evenly and rapidly from the coast to a few miles N.W. of Conway, and from there to near

Florence there is a marked decrease in rate of rise of the floor. The magnetometer demonstration of the two gradients in the coastal plain floor was strengthened by evidence from the two deep wells near the coast, one in Wilmington and the other at Fort Caswell, a few miles south of Wilmington. Here the gradient of the floor was shown to be much steeper than that of the floor inland from Wilmington.

When Havelock well was drilled to a depth of 2318′ to the crystalline floor, its depth showed the floor at that point to be deeper than one would expect from the general gradient of the floor as established by the three wells to the northwest of Havelock. The deep well at Morehead City which reached the crystalline basement at 4044′ shows a gradient of the basement of about 119′ per mile between this well and the Havelock well. This later drilling confirmed the earlier evidence gained from the Wilmington-Fort Caswell wells and the magnetometer cross-section from Myrtle Beach to Florence, and clearly demonstrated the presence of two persistent slopes in the floor of the coastal plain, the steeper one near the ocean.

From this evidence and the hypothetical position of the intersection of these two slopes, assumed to be planes, a generalized cross-section has been drawn through the Havelock and Morehead City wells. And onto this cross-section the Hatteras well was projected along a line parallel with the line of intersection of the two floor planes. When so drawn the crystalline floor beneath the Hatteras well is shown as approximately 9000′ below sea level.

These two slopes of the coastal plain floor are interpreted as the Schooley Peneplain and the Fall Zone Peneplain respectively. In the generalized cross-section the Schooley Peneplain has a gradient of about 13′ per mile and is represented by erosional remnants in the piedmont to the west of the fall-line for some distance. The line of intersection of these two planes seems to approach and finally cross the fall-line northeastwardly from the Havelock-Morehead City cross-section, probably in the upper Chesapeake Bay region.

The oceanward extension of the general cross-section made from data taken from Tectonic Map of U. S., 1944, shows a very rapid descent into the deep ocean less than 30 miles east of Hatteras with slopes of several hundred feet per mile. The presence of the Gulf stream within 20–25 miles of shore and the configuration of the depth lines on Tectonic Map suggest active erosion of continental shelf in this area.

Upper Devonian Bioherms in Central Arizona. J. W. HUDDLE and E. DOBROVOLNY. (Published with permission of the Director of the Geological Survey, U. S. Dept. of Interior)

The late Paleozoic rocks exposed in central Arizona were studied as one of the oil and gas investigations of the U. S. Geological Survey. Some of the results of this work were published as Preliminary Chart No. 10 of the Oil and Gas investigation series, but the text of this report was limited and the purpose of this paper is to present some additional information on the stratigraphy of the Upper Devonian Martin formation.

The Martin formation is exposed in the vicinity of Globe and Lake Roosevelt and in a belt along the Mogollon Rim from the Fort Apache Indian Reservation to the vicinity of Pine and Payson, Arizona. The formation is absent in places and ranges in thickness from a few feet to about 420 feet. It lies unconformably on Cambrian and pre-Cambrian rocks and is overlain by the Mississipian Redwall limestone. The variation in thickness of the Martin formation is due principally to overlap, since the Upper Devonian seas spread over a region of moderate relief in central Arizona. Some of the higher hills may have remained islands in the Upper Devonian seas but some of the pre-Devonian topography was completely buried with sediments. In the western part of the Ft. Apache Indian reservation the lower part of the Martin formation abuts against a cliff of pre-Devonian quartzite, 200 feet high, and only the upper part of the formation continues northward. Near the buried cliff the Martin formation contains some angular boulders of quartzite, probably derived from the cliff, but this coarse material is extremely local and dolomitic limestones nearly free of sand grains are present a few hundred yards south of the cliff. Similar conditions existed near Pine and Christopher Mountain, Arizona.

Several features of the Martin formation indicate that it was deposited in shallow water. Many of the limestones contain grains of quartz in cross-bedded streaks and scattered through the rock. The presence of these sand grains and the indication of current action in the cross-bedding is evidence that the rocks were deposited in shallow water. The lower part of the formation includes brecciated dolomitic limestones which appear to have been formed by submarine slumping and wave and current action. Most of the beds in the formation tend to be lenticular and are traceable only short distances. This is especially true of the cross-bedded sandstones in the middle and upper parts of the formation. The lenticular limestone beds commonly contain abundant corals and stromotoporoids and probably formed as low organic mounds or bioherms rising above the floor of the Devonian sea. The bioherms are most common in the middle and upper parts of the formation in the western part of the Fort Apache Indian reservation. They grew on top of the rocky submarine ridges, probably in very shallow water. The beds between the bioherms are sandy dolomitic limestones and limy sandstones, usually thin-bedded. The presence of the bioherms explains the extreme variation in the sections measured a few hundred feet apart.

Bioherms are also present in the limestones near the middle of the Martin formation in other parts of the area studied.

Copper in the Midland Counties of North Carolina. E. W. BERRY.

In the counties of Chatham, Moore, and Lee there are some sixteen prospects and/or mines which are credited with the production of copper ores over a long period of years. Most of them apparently reached their peak before the turn of the century and of them glowing tales of production are told, which I am afraid must be relegated to the realms of legend and wishful thinking.

The southwest portion of Chatham County had a shaft put down in the fall of 1943 but activity ceased before the shaft was carried to a convincing depth.

A nearby property had some five shallow drill holes put down in 1944 and several trenches dug but no subsequent production. Copper was leached from the material in the fall of 1942 and the spring of 1943 and it is understood that some 260 tons of ore were removed from the property at that time for leaching.

Lee County has one old mine, which supposedly has one shaft 200 feet deep and one shaft 800 feet deep. Moore County has two abandoned holes, one rumored several hundred feet in depth, and another an adit 75 to 100 feet along the incline.

Rumor has it that from these three counties during an early development of copper mining there was produced sufficient copper to "fight the second World War." The increase in interest and price of copper in this present World War stimulated prospecting again in this area, but the only copper recovered was recovered as a copper salt and no metallic copper was shipped. The copper minerals observed are Malachite, Azurite, Chalcocite, Covelite, Bornite (?), and Chalcopyrite.

The Development of the Guinea Pig Ovary From Sexual Differentiation to Maturity. C. G. BOOKHOUT.

Thirty-four closely timed stages from the 27-day embryo to sexual maturity were studied to determine the germ cell cycle in the developing guinea pig ovary.

The medulla is formed by the thirty-fifth day of embryonic life. There follow five distinct waves of ovogenetic activity, two in the embryonic and three in the postnatal ovary. The first period of proliferation is by an ingrowth of broad cell cords from 40 to 48 days of embryonic life. The second proliferation from 58 to 64 days of embryonic life; the third from 6 to 16 days after birth, and the fourth at 24 days is by enlargement of cells within the germinal epithelium. The fifth period of ovogenetic activity occurs at 48 days, just before sexual maturity. It differs from the others since it is expressed chiefly by an ingrowth of slender cords of small germinal epithelial cells which form oocytes or follicle cells within cell nests in the tunica albuginea or in the periphery of the cortex. The history of the first four lines of cells is followed and the methods of degeneration given.

The Metazoa Parasitic in Cotton Rats of Wake County. REINARD HARKEMA.

A parasitological survey of 200 cotton rats collected from two different localities in Wake County was made during 1939–1942. The cotton rat is usually parasitized with at least one species of endoparasite. Arthropods were not very common. Only eight hosts were found to be entirely free of Metazoa.

The following list of parasites found shows the number of hosts infected and the average number of parasites per infected host:

Cestodes: *Hymenolepis diminuta:* 44, 6.22; *H. microstoma:* 4, 32; *Raillietina bakeri:* 61, 8.09; *Paranoplocephala omphalodes:* 3, 2; larvae of *Taenia taeniaformis:* 32, 1.75.

Nematodes: *Longistriata adunca:* 151, 38.48; *Mastophorus muris ascaroides:* 99, 10.92.

Mites and Ticks: *Atricholaelaps glasgowi:* 5.8, 7.05; larvae and nymphs of *Dermacentor variabilis:* 35, 4.14.

Louse: *Hoplopleura hirsuta:* 8, 1.75.

Fleas: *Nosopsyllus fasciatus:* 2, 1.5; *Peromyscopsylla scotti:* 2, 1.5; *Ctenophthalmus pseudagyrtes:* 3, 1.66; *Stenoponia americana:* 1, 3; *Epitedia wenmanni:* 2, 1.5.

The identifications of *R. bakeri* and *Paranoplocephala omphalodes* are provisional. *R. bakeri* as found in the cotton rats compares favorably with the described form found in the squirrel by Chandler, except that it is not as delicate a worm as originally described. These specimens possess the same size scolex, suckers, rostellum, etc., as described by Chandler. However, the strobila are much longer and wider than his material. It may be that the difference in host accounts for the variation. Further work is contemplated on this species.

Only a few *Paranoplocephala omphalodes* were found and the provisional identification appears necessary under the circumstances.

Mention should be made that the filarial worm, *Litosomoides carinii*, and the tapeworm, *Schizotaenia sigmodontis*, were found in earlier studies on the cotton rat but they were not present in this survey.

Litter and Soil Animals of the Duke Forest. A. S. PEARSE.

From 576 samples collected from litter and depths of 0–2 and 2–5 inches throughout a year and passed through Berlese funnels, 353,032 animals were counted. This indicated an average of 1719 per square foot or 2,590,082 per square acre from four forest types (1) oak on clay, (2) pine on clay, (3) oak on sand, and (4) pine on sand. An average of 65% of the animals came from litter, 30% from a depth of 0–2 inches, and 5% from 2–5 inches. In litter characteristic animals were, in order of abundance: mites, collembolans, thysanopterans, insect larvae, ants, chelonethids, various insects, diplopods, spiders, chilopods, earthworms, termites, snails, nematodes, and phalangids. In soil, proturans, iapygids, symphylans, pauropods, and a staphylinid beetle (*Maystia* sp.). Soil moisture appeared to be more effective in controlling number of animals than variations in temperature or hydrogen-ion concentration.

An Automatic Valve for the Measured Delivery of Liquids. L. B. RHODES.

A valve adapted for the controlled delivery of liquids from vessels in measured volumes has been described. A form was exhibited which consisted of a plunger sealed in a glass jacket and containing an iron core for control by a solenoid coil, and also a metallic powder for a dampener. The movement of the plunger to open or close the channel was guided by constrictions in the inclosing jacket. By-passes were provided past the constrictions and a delivery outlet for attachment to burettes or other containers. The valve is operated by various forms of switches and it is very responsive to the stop or start of the electric circuit.

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY

1944–1946

434TH MEETING, OCTOBER 10, 1944

C. DALE BEERS: *Some Factors Affecting Encystment in the Ciliate Tillina magna.*
R. L. HOLMAN: *Observations on Arterial Disease.*

435TH MEETING, NOVEMBER 14, 1944

R. L. MCKEE: *Hydantoins as Anti-convulsants.*
F. W. ELLIS: *The Mechanism of Action of the Sulfonamides.*

436TH MEETING, DECEMBER 12, 1944

E. P. HIATT: *Water Balance in Marine Vertebrates.*
H. W. CRANE: *The Environmental Factor in Sexual Inversion.*

437TH MEETING, JANUARY 9, 1945

A. T. BRAUER: *Some Unsolved Elementary Problems in Mathematics.*
A. J. LEHMAN: *A Demonstration in Scientific Crime Detection.*

438TH MEETING, FEBRUARY 13, 1945

W. S. PLYMALE: *The Trend in the Use of Ultra High Frequencies.*
H. G. BAITY: *Health and Sanitation in the Rio Doce Valley of Brazil.*

439TH MEETING, MARCH 13, 1945

A. T. MILLER: *Studies on Hemorrhage.*
J. W. STRALEY: *The Neutron.*

440TH MEETING, APRIL 10, 1945

S. E. SMITH: *The Gas Permeability of Cellulose Films.*
C. A. VILLEE: *A Problem in Physiological Genetics.*

441ST MEETING, MAY 8, 1945

S. B. KNIGHT: *pH and Indicator Constants in Mixed Solvents.*
G. C. KYKER: *Photodecomposition of Quinine and its Effect on Antimalarial Activity.*

The following officers were elected for the year 1945–46:

President—J. Edison Adams.

Vice-President—Edwin C. Markham.

Recording Secretary-Treasurer—Claiborne S. Jones (for two-year period).

W. C. Coker, E. C. Pliske, W. F. Prouty and E. T. Browne continue on the Editorial Board and E. T. Browne continues as Corresponding Secretary.

E. A. BRECHT
Recording Secretary-Treasurer

442ND MEETING, OCTOBER 9, 1945

E. H. NEWCOMER: *On the Duality of Mitochondria in Plants.*
J. W. STRALEY: *Coriolis Forces in Molecules.*

443RD MEETING, NOVEMBER 13, 1945

D. P. COSTELLO: *A Leptocephalus Larva from Eel Pond, Woods Hole, Massachusetts* (with moving picture illustrations).
T. F. HICKERSON: *Azimuth or Time by Five Selected Stars.*

444TH MEETING, DECEMBER 11, 1945

J. B. MIALE: *The Possible Rôle of the Lymphatics in the Production of Immune Bodies.*
O. K. RICE: *Photochemistry with Intermittent Light.*

On the recommendation of the Executive Committee, it was voted to make a special contribution of $100 to the Mitchell Journal to be used in partial payment of the deficit incurred in the publication of its Sesquicentennial volume.

Dr. W. C. Coker announced his resignation, effective at once, as editor-in-chief of the Journal, and he also made a motion that the Executive Committee canvass the field and recommend to the Society a successor to be elected to this office. This motion was seconded and carried. On a motion by Dr. W. C. George, a rising vote of appreciation was given Dr. Coker for his long years of service as editor-in-chief of the Journal.

445TH MEETING, JANUARY 8, 1946

J. W. HUDDLE: *The Geologic Structure of the Rangely Anticline, Colorado.*
NATHAN ROSEN: *The Betatron.*

On the recommendation of the Executive Committee, Dr. John N. Couch was elected to succeed to the editorship of the Mitchell Journal for the unexpired term of Dr. W. C. Coker, resigned. It was also moved and carried that the next volume of the Journal be dedicated to Dr. Coker.

There was some discussion of plans for the future of the Journal but nothing definite was decided.

446TH MEETING, FEBRUARY 12, 1946

J. E. LARSH, JR.: *Studies in Mice on the Effect of Alcohol on Resistance to the Dwarf Tapeworm of Man.*

447TH MEETING, MARCH 12, 1946

W. C. GEORGE: *The General Biology of the Skeleton.*

448TH MEETING, APRIL 9, 1946

R. L. HOLMAN: *The Relationship of Diet and Kidney Disease to Arterial Disease.*
G. R. MACCARTHY: *Hunting Iron Ore in North Carolina and the Adirondacks.*

It was moved and carried that the President appoint a committee of three

to draw up appropriate resolutions on the occasion of the recent death of Dr. Milton J. Rosenau.

449TH MEETING, MAY 14, 1946

P. E. SHEARIN: *Cosmic Rays.*

W. R. STRAUGHN: *Germicidal Properties of Isopropyl Alcohol.*

On behalf of the special Resolutions Committee (J. J. Wright, chm., H G. Baity, and W. deB. MacNider) Dr. MacNider read the resolution expressing the Society's sorrow at the death of Dr. Milton J. Rosenau. This resolution is appended below.

The following officers were elected:

President, 1946–47—H. G. Baity.

Vice-President, 1946–47—F. C. Erickson.

Corresponding Secretary, 1946–51—E. T. Browne.

Editor of the Journal, 1946–51—J. N. Couch.

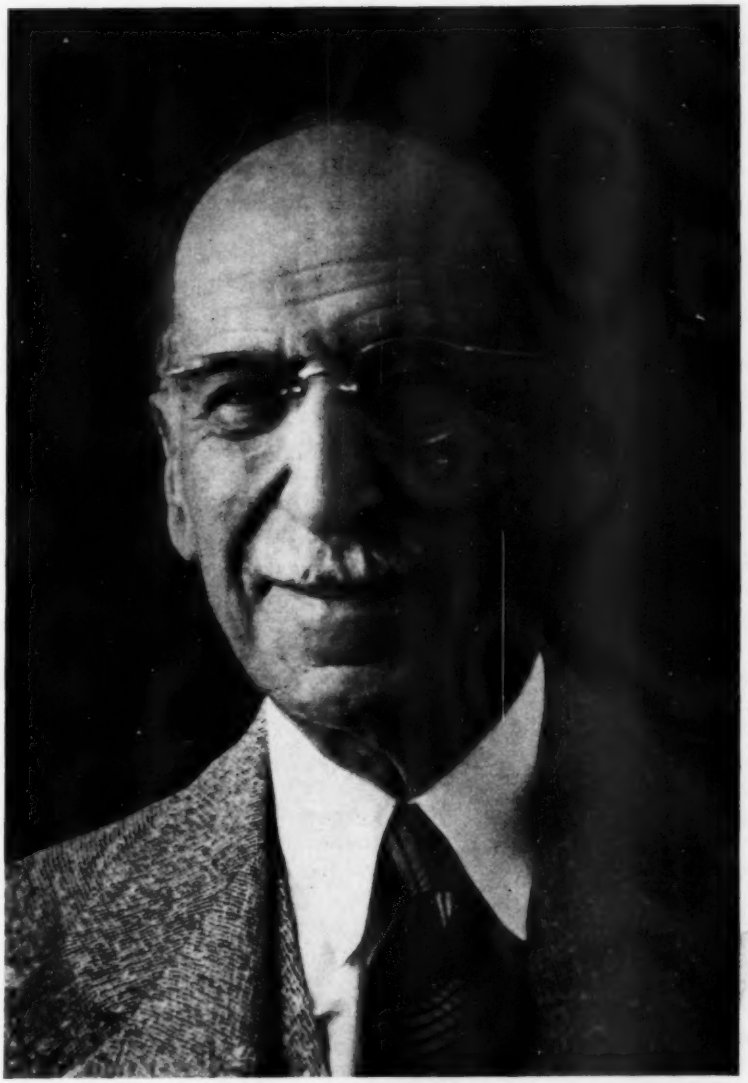
Associate Editors, 1946–51—E. C. Pliske and W. F. Prouty.

CLAIBORNE S. JONES,
Recording Secretary-Treasurer

MILTON J. ROSENAU

By the death of Milton J. Rosenau on April 9, 1946, the world lost a pioneer and leader in Science and Public Health. For fifty-six years his life had been devoted to the promotion of health, the conquering of disease, and the prolongation of life of his fellow man. He, himself, was privileged to live his life to a happy and productive old age. Instead of retiring and enjoying a well earned rest ten years ago, he came to the University of North Carolina where he threw all his effort and experience and influence into the development of the School of Public Health. Its growth and expansion and its recognition as a young leader among the schools of public health was a fitting reward for his devotion to its purpose.

Doctor Rosenau was born in Philadelphia, Pennsylvania, on January 1, 1869. He graduated from the University of Pennsylvania School of Medicine in 1889. In 1890 he began his illustrious career in public health by entering the U. S. Marine Hospital Service which later became the U. S. Public Health Service. This service took him to many parts of the world and his interests in a wide range of problems soon became manifest. At the age of 29 he became director of the Hygienic Laboratory of the U. S. Public Health Service later to become known as the National Institute of Health. Here he developed the method for the standardization of diphtheria antitoxin and then of tetanus antitoxin. His pioneer work in immunology resulted in fundamental contributions to the knowledge of anaphylaxis, serum sickness, and in the field of allergy. His researches made invaluable contributions and discoveries in the control of yellow fever; of typhoid fever; of tuberculosis; of pneumonia; of influenza; of smallpox; of rabies; of infantile paralysis. Other investigations were conducted by him on foot and mouth disease; on plague; on tropical diseases; on rats and their



MILTON J. ROSENAU

(1869–1946)

relation to public health; on disinfection; and on other problems of hygiene and sanitation. He was a pioneer in the promotion of pasteurization of milk and butter and his work on milk-borne diseases was instrumental in the development of pasteurization in this country.

In 1909, he was invited to the newly established chair of preventive medicine at the Harvard Medical School. He thus became the first full-time professor of the first Department of Preventive Medicine and Hygiene in any medical school of the world. He occupied this chair for 26 years. Thus he introduced a new subject into the medical curriculum. He developed a new technique for the teaching of preventive medicine and hygiene and his department became a center of research in epidemiology and advancement of knowledge in the field of public health. His work attracted many talented men to his department and his influence soon became world wide.

Dr. Rosenau's wide vision of the growth of public health in this country led him to realize that training physicians to practice preventive medicine as an integral part of clinical practice was not enough. He saw that a new type of training was necessary to prepare a special group of men to carry out the highly specialized duties of health officer. In 1913, in collaboration with Professors Whipple and Sedgwick of Massachusetts Institute of Technology, he organized a formal course of training for health officers under the name "The School of Public Health of Harvard University and Massachusetts Institute of Technology." Dr. Rosenau became its first Director and held this position for nine years. In 1922 he became Professor of Epidemiology in the School of Public Health which he helped establish at Harvard and held this position together with the Professorship of Preventive Medicine and Hygiene of Harvard Medical School until his retirement at the end of 1935.

Dr. Rosenau served in the Navy in World War I as Lieutenant Commander then as Commander. He was retired from the Navy as Captain in 1927.

Upon his retirement from Harvard he was prevailed upon to come to the University of North Carolina to devote his energy and experience toward organizing the Division of Public Health of the Medical School of the University. He was director of that Division and Professor of Epidemiology. The Division became the School of Public Health of the University of North Carolina and Dr. Rosenau became its Dean, which position he held at the time of his death.

His influence and his inspiration as a teacher was felt by all who were privileged to hear him. But the influence and inspiration of his writing extend to the far corners of the earth. His papers were legion; his contribution to science original and fundamental, his work careful, painstaking and reliable. His facility for clear, concise observation and statement was well recognized. His first published book was "Disinfection and Disinfectants" in 1901. His next book was "The Milk Question" in 1912. This small book is in large part responsible for the safe and healthful supply of milk we enjoy today. His "Preventive Medicine and Hygiene" first published in 1913 and now in its 6th edition is a classical work, is recognized as the best and most comprehensive text on this subject and is called the "Bible of Preventive Medicine." It has been published in five languages, including the Chinese.

Dr. Rosenau's talents and accomplishments did not go unrecognized by his colleagues. In 1912, he was awarded the Gold Medal of American Medicine for Service to Humanity. In 1934, he was awarded the Sedgwick Memorial Medal by the American Public Health Association for outstanding contribution to and promotion of public health. In 1945, he received the Pirquet Gold Medal of the Seventh Forum on Allergy for his outstanding contributions to allergy.

His counsel and guidance were widely sought in official governmental capacity as was shown by his membership on the Advisory Board of the National Health Council; of the National Research Council; and many international committees and councils and conferences on which he was invited to serve.

The wide scope of his interests and his recognition among his fellow scientists were shown by his election to the presidencies of the American Society of Epidemiologists; the American Association of Immunologists; the American Association of Medical Milk Commissions; the Society of American Bacteriologists; the American Society of Tropical Medicine; The Elisha Mitchell Society; and The American Public Health Association. The last position he held at the time of his death.

Doctor Rosenau was a benefactor of mankind. Because he lived, untold numbers are alive today. During his life he labored tirelessly, conscientiously, and capably to conquer sickness; to remove the causes of disease and to prolong life. We, who knew him, are fortunate. His influence and his inspiration will never die.

JOHN J. WRIGHT
H. G. BAITY
WM. DEB. MACNIDER

THE CENTER OF ORIGIN THEORY

By Z. P. Metcalf

Department of Zoology and Entomology, State College, Raleigh, North Carolina

Plates 23–41

The science of zoology is like a living organism in that its proper growth and development is dependent not only upon the expansion of the subsciences which compose it but also upon the proper coordination and correlation of these subsciences. Too frequently in these days of specialization the specialists in various areas proceed as if it were possible to ignore this fundamental law. Systematic zoology cannot develop properly without careful consideration of the recent advances in morphology, genetics, ecology, physiology, zoogeography, embryology and phylogeny.

The reverse is equally true. There can be no substantial progress in the other branches of zoology unless the work is based on sound systematics. Occasionally workers in other branches of zoology attempt to belittle the work and the workers in systematic zoology, and not infrequently taxonomists are urged to return to the principles enunciated by Linnaeus nearly two centuries ago. The fundamental fallacy in this plea is, of course, the indisputable fact that we are much nearer the truth today in systematic zoology than we were in the time of Linnaeus. This is asserted in spite of the fact that systematic zoology has become almost completely bogged down in a morass of nomenclature from which I am by no means sure it can extricate itself. The fact that some of our common animals have been known by anywhere from ten or a dozen to fifty or more different names during the last century should give us pause. The further fact that not even the specialists in mammalogy, ornithology, herpetology, ichthyology or entomology can give us the correct scientific names for common species in their special groups without long and laborious research through the literature is somewhat of a disgrace. Various and sundry abortive attempts have been made by fiat or decree to fix names but I believe we will make no permanent advance toward this much to be desired goal until we re-adopt as the basic principle the law of priority and stick to it through thick and thin. For the moment it might seem best to most of us to adopt the name we learned for a given species or even the last name used but in the long run I am sure this will not be true. Coupled with this must be a careful consideration of the facts based upon a restudy of the evidence in the light of the times when the work was produced. Linnaeus' and other early writers' descriptions of genera and species are totally inadequate, their concepts of the higher categories are entirely different when judged by modern standards. Yet these names must stand and must be adapted to our modern concepts, just as our concepts of today will have to be modified to fit the needs a century or two hence. Such a return to basic concepts will of necessity mean a more careful restudy of the literature of zoology than any thus far made.

It is going to mean that we must have more careful and more complete catalogues of all groups of animals than any which have been published up to the present time.

Furthermore, the desirable end of a better systematic zoology is not going to be met without the systematists doing a more systematic job than they have done. This involves not only more care in our study of nomenclature, but as I have attempted to point out in another connection, it involves a more studied attention to the details of the making of keys to, descriptions of, and illustrations of the prime categories of the animal kingdom. And, lastly, and perhaps more important, it involves the careful correlation of advances in all fields of zoology with systematic zoology by the systematists and in turn the correlation of systematics with the other branches of zoology by the specialists in these fields. (Metcalf, 1937c).

Gone are the happy days of the early taxonomists, like Linnaeus, who could describe a species of animal by a single line of Latin words which referred to external characters only. The systematist who hopes to make a lasting contribution to science in the future must know not only the basic laws of nomenclature, he must have also the ability to write descriptions that characterize, make drawings that delineate and construct keys that guide other students unerringly on the right path to the correct name. But above these cardinal virtues of all good systematic zoologists he must understand the basic principles of morphology, genetics, ecology, embryology, phylogeny, paleontology, physiology, zoogeography and other branches of zoology so that he is able to trace the basic truths through the maze and confusion of tongues which is the science of modern zoology. On the other hand it is equally the responsibility of the specialists in these other areas to understand the fundamental principles of systematic zoology. It will not do to try to shrug off all work in systematics because some work in this field has been superficial or because much of the work in nomenclature is apparently unnecessary. Neither can we ever hope to have again a simple system such as we had in the days of Linnaeus. But even a cursory examination of the estimated figures for genera and species of animals known in the middle of the Eighteenth Century and known today cannot fail to impress the reader with the tremendous advances that have been made in systematic zoology in less than two centuries. In 1758 Linnaeus described some 300 genera and 4,200 species, but as near as I can estimate there have been described, as of today, at least 200,000 genera and 2,500,000 species (Metcalf, 1940a).

With these thoughts in mind, I desire to emphasize in the present paper the interrelations between zoogeographic regions and genera. In a previous paper (Metcalf, 1933) I tried to point out that there was a close correlation between zoogeographic regions and taxonomic groups.

The practical completion of the card catalog of the Homoptera of the world makes it possible for us to study the interrelations between systematics and zoogeography. This catalog was set up so as to show the geographical distribution of the species of each genus strikingly.

The sample is large enough, about 30,000 species in approximately 3,000 genera, to make any tentative conclusions worthy of considerations. The Homoptera are very valuable as geographic indices. In the first place they are insects of relatively small size, without strong powers of locomotion. This together with the fact that for the most part species are limited to a single host plant or a very narrow range of food plants results in their being limited to a very gradual spread in nature. Many species not limited to a single species of host plant are limited to a relatively narrow range of host plants. Others not limited by food preference seem to be restricted to ecological niches. In addition, their distribution is apparently greatly influenced by other ecological factors not too clearly understood at the present time (Metcalf, 1924a; Metcalf and Osborn, 1920a). This makes these insects, popularly known as cicadas, tree hoppers, leaf hoppers, plant hoppers and frog hoppers or spittle insects, excellent indicators of zoogeographic regions. The apparent limitations in the use of these forms for this purpose are the fact that most of these forms are small or very small inconspicuous insects and have not been as generally collected as the larger and more conspicuous vertebrates. In the second place this order of insects is one of the least known, taxonomically speaking, of all the orders of insects. This is due to a combination of circumstances. Prominent factors in this lack of knowledge are the facts that generic limits are poorly understood and that specific characters are often obscured and it is only recently that some of these characters have been appreciated and studied. The following purely tentative conclusions are advanced for consideration.

If the terms genus and species are phylogenetic as well as systematic concepts, the species composing the genus will be closely related. They will have similar morphological characters, not merely similar appearing characters. In other words if living organisms have evolved from preexisting organisms, or if evolution be accepted as a natural law in the organic world, and if there is any reality in the taxonomist's concepts of the individual, the species, the genus, the family, the order and phylum; then there is a spot on the earth's surface where each category originated. For the lowest category, we call this place the birthplace of the individual. For the higher categories, we call this area the center of origin for the group under consideration, be it species, genus, family, order or phylum. Each species will have a center of origin and each genus will also have a center of origin. These centers of origin will bear the same relation to the species or the genus zoogeographically as his birthplace bears to the history of the individual. The center of origin of a group has a geographic location, which will be more definite for the lower categories, such as species and genera, than it will be for the higher categories, such as families and orders; just as the birthplace of an individual, if it can be determined, is more definite than the center of origin for a species even if the center of origin can be approximated. In the same way, in general, the center of origin for a species will be more recent, geologically speaking, than it will be for the higher groups.

Usually the center of origin for a species will be within the present range of the

species, but not necessarily so. The center of origin of a genus may be within the range of the known species; but is more apt to be beyond the range of the included species, than the center of origin for a species is apt to be beyond the known range of this species.

In the highest categories the center of origin is frequently very remote geologically and geographically; and may have no apparent relation to the present distribution of the recent forms. In fact only a very few of these racial histories have been traced. But the generalized histories of the horse family and elephant family make one of the most interesting chapters in paleontology. These somewhat fictionalized histories are developed in the illustrations (Pls. 23 and 24) and are repeated here not because they are not well known; but only because they may help us to an understanding of the theory of centers of origin which I wish to apply to certain generic groups later.

In the same way the spread of certain introduced species may help us to a better understanding of this theory. The spread of the English sparrow, the starling (Pl. 25), and the cotton boll weevil (Pl. 26), reveal the same fundamental pattern. For a period after introduction there is very little spread, then gradually the rate of spread increases and reaches a climax when the animal has occupied all the territory available to it, that is, to all the territory to which it is adapted ecologically. With the cotton boll weevil this would mean all that area in the southeastern United States where cotton is grown except certain upland areas where either winter temperature or low humidity seems to be a determining factor. From this climax of wide distribution there may be a gradual recession until the species occupies only the most favorable islands in the territory that it has occupied. Eventually the enemies of this species may gain the upper hand and it may disappear entirely from the territory that it once occupied.

There are usually seven fairly distinct stages in the spread of introduced species. First, a period when it is becoming established, typically restricted to a very limited area; then a period when it commences to spread; third, a period of increased dispersal; fourth, a period of maximum development; fifth, a slight and gradual recession; then a period of rapid recession; and finally a period of great reduction in range or complete elimination.

It may be argued that these accidental introductions have no resemblance to the dispersal of a species in nature. That in the latter case the spread is slow; occupying periods that are measured by geological epochs not in years; but let's not be too sure that this is the case. Is it not possible that the spread of species in nature is fully as rapid as that of introduced species? Introduced forms which find themselves in a new but favorable environment usually find no great numbers of enemies arrayed against them. May this not be equally true of newly evolved forms? I rather suspect, if we knew the complete history of a species, that we would find that it runs about the same course that we have seen repeated in this country by several introduced forms.

From its center of origin a species will spread until it occupies all the territory, ecologically speaking, to which it is adapted. But sooner or later any

species in its dispersal will presumably meet with impassible barriers: the ocean for terrestrial species, high mountains for lowland species, temperate climates for tropical species; and many other ecological and physical barriers. Within the continental range of a species there will be many areas which a highly modified species cannot occupy. If the species is restricted to a single host plant species, obviously it will not be able to live on other host plant species of the same genus which may be available. If the given species is restricted to a single ecological niche, then other ecological areas may be available in the area occupied by the species under consideration. Other species may develop for the food plants which are not used or the ecological areas which are not occupied. In this way an area may support many closely related species. Such a group of species would constitute a phylogenetic genus. The geographic extent of such a phylogenetic group becomes of special interest not only to the systematist but to the student of zoogeography, for it too will have a center of origin. Tentatively we will advance the idea that the extent of such a genus would be bounded by a zoogeographic region. If this is true, a group of genera may be used to delimit a zoogeographic region and a zoogeographic region may be used to define a genus. Any such concept must be used in the broadest sense until we are much surer of our facts than we are at the present time.

Such a concept is based upon a number of assumptions which may or may not be true. Some of the assumptions may apply to animals with limited powers of locomotion, such as the Homoptera, and not to other animals like birds with practically unlimited powers of flight. Some of the assumptions on the other hand may not be true for recently evolved groups like the mammals which may be in a state of flux, evolutionarily speaking, but could be true for animals like the ancient insects with their external armor of inflexible chitin which may have settled into evolutionary grooves. Some may apply to animals which have only limited powers of adaptation to the environment while not applying to other animals which have a wide range, ecologically speaking.

For the present, at least, it is my belief that it is not possible to develop a single zoogeographic map for all groups of the animal kingdom. The attached map (Pl. 27) has been developed during the past twenty-five years and fits my present classification of the Homoptera better than any other scheme I have been able to advance.

This map indicates my present conception of the zoogeographic regions of the world as delimited by the Homoptera. This would not be the regions of the world for mammals or any other group of animals which have better methods of locomotion, or different sets of ecological factors limiting their ranges, or different centers of origin, or different rates of spread. It should be recalled, also, that it is difficult to locate boundaries between regions in nature. Regions for land animals unless separated from each other by large bodies of water, merge gradually into each other. Therefore, on this map I have drawn the boundaries as broad areas in certain parts of the world, and by narrow lines in other places. This lack of definiteness may be due, also, to lack of knowledge, for it must be emphasized repeatedly that our knowledge of the Homoptera

is far from complete. Our knowledge of genera and species, especially in certain families, is fairly complete. Such regions as Europe and the United States have been fairly well studied for many groups. But, for other groups, even these regions are poorly known. The recent studies of three genera of North American leaf hoppers, *Empoasca*, *Typhlocyba* and *Erythroneura*, by such students as Beamer, De Long, Knull, Oman and others, illustrate the results that may be expected when other genera are as carefully studied. The species of these three genera are almost exclusively pale green insects, sometimes with varieties that are vittate, fasciate or spotted with bright red, but for the most part without evident external specific characters. Using the characters of the male genitalia as criteria in the study of specific limits in these genera these students have revealed that what were considered as small genera with only a few species a quarter of a century ago, now stand revealed as genera with a large number of species. Gillette (1898) in his monographic study of this group of leaf hoppers described 28 species of *Empoasca* and 21 species of *Typhlocyba* and *Erythroneura*. In 1917 Van Duzee cataloged 32 species of the genus *Empoasca*, 11 species of *Typhlocyba* and 14 species of *Erythroneura*; but today we know no less than 99 species of *Empoasca*, 57 species of *Typhlocyba* and 296 species of *Erythroneura*. Therefore, any theories that are advanced today about genera and species of Homoptera are purely tentative and will be subject to constant revisions until that happy day when we know more thoroughly their taxonomic and geographic limits. Homoptera from the other regions of the world have been studied only superficially. Many genera have been poorly defined. This is in part due to a failure to appreciate true morphological characters. It is due in part, at least, to the fact that the generic characters inherent in phallic structures have not been recognized. And it arises from a lack of consideration of the importance of delineations of zoogeographic regions as fundamental characters in the definition of genera.

This map differs from the conventional map in the following respects: New regions proposed are Caribbean, embracing Mexico, Central America and the West Indies; Malaysian, embracing the Sunda Islands, the Philippines and Celebes; Austromalayan, comprising New Guinea, Solomon Islands, New Hebrides and New Caledonia; Maorian, including New Zealand and the nearby islands.

Whether any of these regions are real zoogeographic regions in the best sense of the word must depend upon more evidence than is now at hand.

In studying this map it must be borne in mind that nature draws no hard and fast lines. The low tide mark may be the extent of the spread of a strictly terrestrial species but no land area is separated from a contiguous land area by sharp boundaries. In such areas species from adjoining areas may tend to overlap, and all boundaries on the map are subject to modification as more evidence is produced. But as indicated on the map there are three great areas where it is practically impossible to define boundaries with our present knowledge of the Homoptera. These areas are indicated on the map by solid black. One is the boundary between the Nearctic Region and the proposed Caribbean Re-

gion. This is a semiarid region with many high mountains. Many Mexican species extend northward into the southwestern United States and on the other hand many species from the southwestern United States especially in the mountains and I suspect equally along the gulf coast tend to extend into Mexico. On the other hand, if we are to establish a Caribbean Region, its southern border is equally hard to define. The great valley of the Orinoco has many close ties with the Caribbean Region but many species from the Amazon subregion tend to extend northward into the valley of the Orinoco.

The other trouble spot on our zoogeographic map is the area in southeastern Asia including southern China, Formosa and Hainan Islands where it is difficult to draw a boundary between the Oriental Region on the one hand and the Palearctic Region on the other. Elsewhere this boundary seems to be fairly sharp across the Himalayas and the Persian Desert.

Most of the other boundaries seem fairly stable with our present knowledge of the Homoptera. The oceans and deserts dividing the great geographic regions are usually effective barriers against land animals such as the Homoptera. Narrow straits, on the other hand, may not be effective barriers to the spread of strictly terrestrial species. The Straits of Florida and Malacca Straits, separating the Nearctic from the Caribbean and the Oriental from the Malaysian, are examples. The southern tip of Florida shows some Caribbean elements and the southern end of the Malay Peninsula contains a mixture of Oriental and Malaysian elements. But what will emerge from the studies now in progress of extensive collections from the Malaysian Region and Austromalayan Region is entirely problematical. Such studies might modify our present concepts of the boundaries between the Oriental Region and the Malaysian Region, on the one hand, and the boundaries between the Malaysian Region and the Austromalayan Region, on the other hand. In fact, further studies may eliminate both the Caribbean Region and the Malaysian Region entirely but for the present they are useful concepts.

From this map has been developed the concept that zoogeographic areas may be used to correct our ideas of systematic relationships and, vice versa, that our ideas of systematic relationships may be used to modify our concepts of zoogeographic map-making. These ideas may be expressed by the following parallel columns:

Zoogeographic Regions	Taxonomic Groups
Superrealm or Realm	Families
Realm or Subrealm	Subfamilies
Region	Genera and Subgenera
Subregion	Species and Subspecies

This classification, if correct, means that it should work both ways. Superrealms or realms should be defined by families (Pl. 29); realms or subrealms by subfamilies (Pls. 30 and 31); and genera should be confined to regions (Pl. 29, *Tragopa*; Pl. 30, *Tettigometra*; Pl. 33, *Sextius*; Pl. 39 and Pl. 41); species to subregions, *et cetera*. Now such a broad generalization does not mean that some

species do not have a broader distribution than a subregion, or that some genera are not distributed over two, three, or more regions. Some species are found in more than one region; in some cases being distributed by man in connection with his cultivated crops. Thus, the corn plant hopper (*Peregrinus maidis* Ashmead) (Pl. 28) was described from Florida, and occurs in the southern states from North Carolina to Texas, and has been found wherever maize is grown in the tropical and warm temperate regions of the world: Ceylon, Hawaii, Queensland, Fiji, Java, throughout the West Indies, India, New South Wales, Mexico, Nicaragua, Brazil, Nigeria, Philippine Islands, Formosa, Malay Peninsula, Amboyna, Borneo, Natal and Polynesia. Certain genera have a wider distribution than a single zoogeographic region. What I am trying to say is that the taxonomist and systematist should look with suspicion on all such cases of wide distribution, especially of uncorrelated distribution. Genera may have isolated species in South America and in India, or in China and South Africa, but such cases are open to very grave suspicion. There may be cases of genera having species which have lost connections with their centers of origin as in the case of the elephant and horse tribes; but such cases should be established only by careful consideration of all the facts. At the present time we have many genera, especially the older established genera, which were very vaguely defined and which have become the dumping ground for a vast host of species simply because the generic descriptions are too all-inclusive. For example, the genus *Delphacodes* Fieber, as at present constituted, contains no less than 48 species in the Nearctic Region, 105 species in the Palearctic Region, 17 species in the Ethiopian Region, 13 species in the Oriental Region, 19 species in the Caribbean Region, 40 species in the Neotropical Region, 6 in the Australian Region, 1 species in the Austromalayan Region, 1 species in the Maorian Region, and 5 species in the Oceanic Region. Now I have no more reason for believing that the genus *Delphacodes* represents the correct systematic position of these 255 species than that the genus *Cicada* represented the correct position of the 42 species described by Linnaeus in 1758. These 42 species are today distributed among 9 families and 16 genera. The correct solution of such taxonomic problems as presented by the complex genus *Delphacodes*, awaits a better understanding of taxonomic characters, zoogeographic distribution, *et cetera*. It is, of course, barely possible that this genus is a very ancient one of world-wide distribution; but it is certainly a safer assumption that it represents a vague complex with poorly defined and very generalized characters of polyphyletic origin. All such cases should be carefully reconsidered and the boundaries of such taxonomic groups should be redefined and modernized. By these and similar methods only will it be possible to make taxonomy a more exact science.

This belief that there is a mutual interrelation between a true genus and a real zoogeographic region is dependent upon our definition of both terms. That both terms need clearer definitions requires no extended argument at this time.

Having laid down certain zoogeographic concepts, let us examine in more detail the relation between these concepts and our knowledge of the Homoptera as a group, systematically speaking. There are two ways in which the genera of the Homoptera may be classified. First, numerically based on the number

of species included in each genus. For this classification we have taken purely arbitrary ranges as follows: genera with a single species; genera with a small number of species, 2-9 inclusive; genera with a moderate number of species, 10-49 inclusive; large genera, with 50-99 species; and very large genera with more than 100 species each.

In the same way we can classify genera on the basis of the geographic distribution of the species included. These would include genera found in a single region only; those found in two or three contiguous regions; genera with most of the species in a single region with a few species in remote regions; and cosmopolitan genera with species in four or more regions.

The relation of these two concepts is clearly shown in the attached Table I.

TABLE I

Size of genera correlated with geographic distribution of species

	NUMBER OF SPECIES IN EACH GENUS				
	1	2-9	10-49	50-99	100
Species confined to a single region	1163	685	65	4	—
Species confined to 2 or 3 contiguous regions	—	454	215	10	1
Species found mainly in one region with scattered species in noncontiguous areas	—	34	63	3	—
Cosmopolitan genera	—	38	67	25	29

Characteristic genera for the various regions are indicated below. Each genus is followed by a number indicating the number of species which have been catalogued from the given region followed by a number or numbers in parentheses indicating the number of doubtful species from other regions.

NEARCTIC REGION

ARAEOPIDAE (formerly DELPHACIDAE)

Laccocera 7

Megamelanus 8
(1 Caribbean, Bermuda)

DERBIDAE

Otiocerus 9
(4 Caribbean)

DICTYOPHARIDAE

Phylloscelis 4

Scolops 31

Deserta 4

ISSIDAE

Fitchiella 8

Bruchomorpha 19
(2 Caribbean,
1 Mexico,
1 Costa Rica)

Neaethus 16

Dictyssa 15

Dictyobia 4

Dyctidea 7

Danepteryx 5

TIBICINIDAE

Tibicinoides 4 *Okanagana* 44 *Clidophleps* 9
Platypedia 17

TETTIGELLIDAE (formerly TETTIGONIDAE, TETTIGONIELLIDAE or CICADELLIDAE)

Neokolla 16 *Errhomus* 6

GYPONIDAE

Xerophloea 12 *Gyponana* 64
(1 Caribbean, Puerto Rico) (2 Mexico)

MEGOPHTHALMIDAE

Tiaja 6

COELIDIIDAE (formerly JASSIDAE)

Memnonia 4 *Aligia* 14 *Twiningia* 10
Osbornellus 28 *Flexamia* 27 *Alapus* 7
Platymoideus 16 *Latalus* 10 *Palus* 8
(1 Palearctic)
Polyamia 32 *Hebecephalus* 32 *Amplicephalus* 8
Amphipyga 9 *Athysanella* 11 *Gladionura* 10
Commellus 5 *Ophiola* 16 *Norvellina* 26
Ballana 66 (Pl. 30) *Cyperana* 13 *Elymana* 5
Arundanus 12 *Graminella* 11 *Allygianus* 4
Colladonus 19 *Conodonus* 5 *Gloridonus* 8
Idiodonus 18 *Pasadenus* 8 *Acinopterus* 21
Tinobregmus 6

IASSIDAE (formerly BYTHOSCOPIDAE)

Acertagallia 22

CICADELLIDAE (formerly TYPHLOCYBIDAE or EUPTERYGIDAE)

Forcipata 9 *Hymetta* 5

MEMBRACIDAE

Publilia 4 *Cyrtolobus* 38 (Pl. 41) *Xantholobus* 10
(1 Caribbean, Mexico) (2 Caribbean)
Glossonotus 5 *Carynota* 5 *Archasia* 4
Telamona 24
(1 Caribbean, 1 Neotropical)

PALEARCTIC REGION

TETTIGOMETRIDAE (Pl. 30)

Tettigometra 34

CIXIIDAE

Hyalesthes 9 *Hemitropis* 8
(1 Oriental)

ARAEOPIDAE (formerly DELPHACIDAE)

Stiroma 6 *Unkana* 13 *Metropis* 8

DICTYOPHARIDAE

Dorysarthrus 4
Sphenocratus 6
Orgerius 21
(1 Nearctic)
Saigona 4
Anorgeriopus 6
Bursinia 14
Nymphorgerius 8

FLATIDAE

Phantia 11
(1 Ethiopian, Eritrea)
Cyphopterum 6

ISSIDAE

Caliscelis 15
(1 Oriental, Ceylon; 1 Neotropical, Rio de Janeiro)
Conosimus 6
(1 Neotropical, Argentina)
Ommatidiotus 12
Mycterodus 10

CICADIDAE

Euterpnosia 13

TIBICINIDAE

Tibicina 10
(1 Neotropical, Chile)
Adeniana 5

TOMASPIDAE

Pseudaufidus 4

CERCOPIDAE

Mesoptyelus 8
Jembropsis 5
Neophilaenus 9

EVACANTHIDAE

Oniella 4

COELIDIIDAE (formerly JASSIDAE)

Distomotettix 7
Stictocoris 4
Doratura 15

IASSIDAE (formerly BYTHOSCOPIDAE)

Symphypyga 5

MEMBRACIDAE

Arisangargara 8

ETHIOPIAN REGION

TETTIGOMETRIDAE

Hilda 10
(1 Palearctic)

CIXIIDAE

Achaemenes 10
Volcanalia 11

DERBIDAE

Lydda 6
(1 Australian)

Phenice 5

Diostrombus 18
(2 Oriental,
1 Palearctic,
1 Locality unknown)

Paraphenice 8

Nicerta 6

DICTYOPHARIDAE

Raphiophora 5

FULGORIDAE

Eddara 5
Holodictya 8

Metaphaena 10

Anecphora 14

TROPIDUCHIDAE

Mulucha 4

Numicia 9

FLATIDAE

Flatina 10
Chaetormenis 4
Flatoidessa 14

Latois 4
Flatosaria 7
Paraflatoides 6

Gyaria 6
Uyzanus 9
Dendrona 5

ISSIDAE

Trienopa 15

Durium 5

Heinsenia 4

RICANIIDAE

Epitemna 9
Pochazoides 13

Ricanopsis 4
Privesa 12
(1 Australian)

Pocharica 11

EURYBRACHIDAE

Paropioxys 19

Aspidonitys 14

Metoponitys 8

CICADIDAE

Munza 12
(1 Loochoo Island)

Ugada 13

Yanga 13

TIBICINIDAE

Quintilia 21
(1 Australian,
1 Locality unknown)
Taipinga 9
(1 Palearctic, China)
Stagira 8
Lacetas 7

Lycurgus 6
(1 Oriental)

Trismarcha 8

Xosopsaltria 5

Psilotympana 4

Malagasia 4

Inyamana 5

TOMASPIDAE

Locris 83 (Pl. 39)
Literna 23

Bandusia 4
Amberana 5

Rhinaulax 4

CERCOPIDAE

Sepullia 14

TETTIGELLIDAE (formerly TETTIGONIDAE, TETTIGONIELLIDAE or CICADELLIDAE)

Wolfella 5

COELIDIIDAE (formerly JASSIDAE)

Palicus 5

MEMBRACIDAE

Xiphopoeus 8
Tricoceps 4
Gongroneura 7
Congellana 4
Platybelus 10
Monocentrus 7
Evanchon 4

AETALIONIDAE

Coloborrhis 4

ORIENTAL REGION

FULGORIDAE

Saiva 9
(1 Malaysian, Borneo)

FLATIDAE

Hilavrita 4

LOPHOPIDAE

Pitambara 6
(1 Malaysian, Borneo)

EURYBRACHIDAE

Eurybrachys 14
(1 Malaysian, Sumatra;
1 Neotropical, French Guiana)
Ancyra 6
Thessitus 4
Lozocephala 4

CICADIDAE

Haphsa 7
(1 Palearctic, Yunnan; 1 Palearctic, Macao; 1 Austromalaysian, New Guinea)
Balinta 6
Khimbya 5

TOMASPIDAE

Callitettix 8 (Pl 39)
Abidama 5
(1 Palearctic; Szechwan)

GYPONIDAE

Tambila 5

CICADELLIDAE (formerly TYPHLOCYBIDAE or EUPTERYGIDAE)

Empoanara 5

MEMBRACIDAE

Hypsauchenia 7
(1 Malaysian)

Coccosterphus 8

Parayasa 11
(1 Malaysian)

MALAYSIAN REGION

DERBIDAE

Zoraida (*Peggiopsis*) 18
(1 Ethiopian; 2 Oriental; 1 Austromalayan)

Leomelicharia 6

Zeugma 6
(1 Palearctic, Formosa; 1 Oriental, Malay Peninsula)

Kaha 10
(1 Palearctic, Formosa; 1 Australian)

Nesokaha 5
(1 Palearctic, Formosa)

TROPIDUCHIDAE

Neocatara 4

FLATIDAE

Bythopsyrna 14

ISSIDAE

Eupilis 5

Syrgis 5

RICANIIDAE

Pochazina 8

LOPHOPIDAE

Menosca 7
(1 Oriental)

Lapithasa 4

CICADIDAE

Maua 9
(1 Palearctic, China)

Ayesha 4

Psithyristria 5

TIBICINIDAE

Prasia 5

TOMASPIDAE

Considia 7
(3 Oriental, Malacca)

Keducarta 4
(2 Oriental, Malacca, Singapore)

Phlebarcys 5

Poeciloterpa 8

Sialoscarta 7

CERCOPIDAE

Flosshilda 5

Plinia 6

MEMBRACIDAE

Pyrgauchenia 9

Pyrgonota 14

Centrochares 5
(1 Oriental, Singapore)

Cryptaspidia 9

AUSTROMALAYAN REGION

FULGORIDAE

Myrilla 7
(1 Malaysian, Buru Island)

CICADIDAE

Sawda 5
(1 Oceanic, Fiji)

TIBICINIDAE

Ueana 8 — *Mouia* 4

AUSTRALIAN REGION

FLATIDAE

Massila 4 — *Dascalina* 5

EURYBRACHIDAE

Platybrachys 16 — *Olonia* 9 — *Dardus* 6

CICADIDAE

Thopha 4 — *Psaltoda* 10 — *Macrotristria* 17

TIBICINIDAE

Burbunga 6 — *Kobonga* 4 — *Pauropsalta* 13
(1 Palearctic, Mediterranean, 1 Oriental)

Urabunana 8

CERCOPIDAE

Bathyllus 4

GYPONIDAE

Vulturnus 7
(2 Oriental, Ceylon)

MEGOPHTHALMIDAE

Stenocotis 9

COELIDIIDAE (formerly JASSIDAE)

Rhotidus 15

EURYMELIDAE

Eurymela 5 — *Eurymeloides* 10

IASSIDAE (formerly BYTHOSCOPIDAE)

Austroagalloides 7

MEMBRACIDAE

Ceraon 8 — *Acanthuchus* 16
(1 Oriental) — *Sertorius* 10

Sextius 14 (Pl. 33) — *Eutryonia* 4

MAORIAN REGION

CIXIIDAE

Koroana 2 *Semo* 1 *Huttia* 2
Malpha 4

OCEANIAN REGION

CIXIIDAE

Oliarus (*Nesoliarus*) 52

ARAEOPIDAE (formerly DELPHACIDAE)

Leialoha 11 *Nesodryas* 24 *Aloha* 10
Ilburnia 79 (Pl. 33)
(1 Ethiopian, St. Helena;
1 Neotropical, Galapagos)

TROPIDUCHIDAE

Vanua 7

CERCOPIDAE

Lallemandana 14 (Pl. 30)
(1 Austromalayan, Loyalty Islands)

COELIDIIDAE (formerly JASSIDAE)

Nesophrosyne 36 *Nesophyla* 8

NEOTROPICAL REGION

ARAEOPIDAE (formerly DELPHACIDAE)

Canyra 8
(1 Locality unknown)
Columbisoga 10
(2 Oriental; 1 Palearctic, Formosa)

DICTYOPHARIDAE

Diacira 6 *Dictyopharoides* 7 *Taosa* 15
(1 Caribbean)

FULGORIDAE

Lystra 6 *Poiocera* 18 *Dilobura* 6
(1 Caribbean) (2 Locality unknown)
Fulgora 6 *Phrictus* 12
(1 Caribbean, Mexico) (2 Caribbean, Panama)

TROPIDUCHIDAE

Alphesiboea 6

NOGODINIDAE

Vutina 5 *Bladina* 5
(1 Caribbean, Panama)

FLATIDAE

Poekilloptera 5 *Phalaenomorpha* 8

ACANALONIDAE

Philatis 6 — *Thiscia* 4

ISSIDAE

Plagiopsis 4 — *Acrisius* 5 — *Heremon* 6

CICADIDAE

Zammara 7 — *Tympanoterpes* 8 (1 Locality unknown) — *Ariasa* 8

Majeorona 6

TIBICINIDAE

Calyria 6 — *Parnisa* 8 — *Tettigades* 7 (1 Palearctic and Caribbean, Arizona and Mexico)

TOMASPIDAE

Baetkia 4 — *Laccogrypota* 12 (Pl. 39) — *Homalogrypota* 4
Ischnorhina 8 — *Mahanarva* 4 — *Tomaspisinella* 13
Hyboscarta 8

CERCOPIDAE

Sphodroscarta 7 — *Balsana* 8 — *Avernus* 4

TETTIGELLIDAE (formerly TETTIGONIELLIDAE, TETTIGONIDAE or CICADELLIDAE)

Dilobopterus 14 (2 Caribbean, Mexico) — *Acrogonia* 4 — *Ciccus* 8
Proconia 23 (2 Caribbean, St. Vincent Island) — *Heterostemma* 4 — *Acrocampsa* 5
Teletusa 9 — *Raphirhinus* 7 — *Stictoscarta* 8
Homoscarta 4 — *Coelopola* 4 — *Abana* 11 (1 Caribbean, Costa Rica)
Myogonia 4

GYPONIDAE

Scaris 6

MEMBRACIDAE

Lycoderes 18 (2 Caribbean) — *Stegaspis* 8 — *Bocydium* 5
Alchisme 12 — *Cymbomorpha* 9 — *Iria* 6
Rhexia 10 — *Sundarion* 5 — *Hemikyptha* 5
Anchistrotus 6 — *Cyphonia* 9 — *Antonae* 7
Centrogonia 12 — *Penichrophorus* 7 — *Hille* 5
Gelastogonia 11 — *Maturna* 7 — *Aphetea* 7 (1 Caribbean, Guatemala)
Tragopa 48 (Pl. 29) (2 Caribbean) — *Erechtia* 30 (1 Caribbean, Mexico)
Membracis 31 (3 Caribbean)

AETALIONIDAE

Biturritia 6

Tolania 11
(1 Caribbean, Cuba)

CARIBBEAN REGION

DERBIDAE

Neocenchrea 4
(1 Nearctic)

FLATIDAE

Antillormenis 9

Flatormenis 9
(1 Neotropical, Ecuador)

ISSIDAE

Colpoptera 13

Picumna 7
(2 Nearctic, Arizona)

CERCOPIDAE

Leocomia 11

TETTIGELLIDAE (formerly TETTIGONIDAE, TETTIGONIELLIDAE or CICADELLIDAE)

Arezzia 6 *Hadria* 6 *Hortensia* 4

COELIDIIDAE (formerly JASSIDAE)

Omanana 12

MEMBRACIDAE

Nessorhinus 4 *Monobelus* 8 *Callicentrus* 6
Poppea 8
(1 Neotropical, Peru)

Extended discussion of the genera with only a single species which are confined to a single geographic region is not needed. Whether they are valid or not would depend upon other factors than the geographic distribution. As may be noted from Table I these constitute more than one third of the known genera.

My belief is that the vast majority of the larger genera which include species from only a single region are true phylogenetic genera. As noted in Table I these constitute more than one eighth of the known genera. Examples of genera of this type may be found in the table of genera characteristic for the zoogeographic regions.

In the same way we may conclude that the vast majority of the genera that are confined to two or three contiguous areas represent true phylogenetic genera. These represent more than one fifth of the known genera. Even though we assume that these genera are valid phylogenetic concepts, we should nevertheless bear in mind that all of them need careful reconsideration to determine whether this validity is anything more than geographic propinquity. Some of the larger genera of this group with their known distribution may be listed as follows:

LARGE GENERA FROM 2 OR 3 CONTIGUOUS REGIONS

CIXIIDAE

Pintalia: 22 Caribbean, 40 Neotropical, 1 Nearctic
Oecleus: 26 Nearctic, 19 Caribbean
Bothriocera: 19 Caribbean, 10 Nearctic, 5 Neotropical

ARAEOPIDAE (formerly DELPHACIDAE)

Stobaera: 7 Nearctic, 6 Caribbean

DERBIDAE

Mysidia: 20 Neotropical, 15 Caribbean

FULGORIDAE

Scamandra: 20 Malaysian, 4 Oriental (Malay Peninsula)
Laternaria: 31 Malaysian, 24 Oriental, 3 Palearctic, 12 Formosa, 1 China

ACHILIDAE

Catonia: 33 Nearctic, 11 Caribbean

FLATIDAE

Anormenis: 15 Neotropical, 6 Caribbean, 3 Nearctic
Neomelicharia: 21 Malaysian, 5 Austromalayan, 3 Australian

ACANALONIIDAE

Acanalonia: 21 Caribbean, 20 Nearctic, 8 Neotropical

ISSIDAE

Bruchomorpha: 20 Nearctic, 4 Caribbean
Aphelonema: 16 Nearctic, 10 Palearctic, 2 Caribbean
Gergithus: 18 Palearctic, 17 Oriental, 7 Malaysian
Hemisphaerius: 54 Malaysian, 17 Oriental, 9 Austromalayan, 7 Palearctic (Pl. 36)
Thionia: 32 Neotropical, 20 Caribbean, 10 Neartic (Pl. 37)

CICADIDAE

Diceroprocta: 22 Nearctic, 18 Caribbean, 2 Neotropical
Cryptotympana: 21 Palearctic, 17 Oriental, 11 Malaysian, 1 Australian
Proarna: 15 Neotropical, 9 Caribbean, 1 Nearctic
Fidicina: 31 Neotropical, 4 Caribbean
Terpnosia: 17 Oriental, 8 Palearctic, 2 Malaysian
Cosmopsaltria: 12 Malaysian, 9 Oriental, 6 Palearctic, 1 Austromalayan
Platylomia: 18 Oriental, 11 Malaysian, 8 Palearctic, 1 Austromalayan
Meimuna: 17 Palearctic, 11 Oriental, 3 Malaysian
Cicadatra: 20 Palearctic, 8 Oriental
Pomponia: 13 Malaysian, 12 Oriental, 2 Palearctic, 1 Austromalayan
Mogannia: 25 Palearctic, 16 Malaysian, 15 Oriental

TIBICINIDAE

Carineta: 39 Neotropical, 5 Caribbean

TOMASPIDAE

Monecphora: 62 Neotropical, 11 Caribbean, 2 Nearctic (Pl. 38)
Trichoscarta: 20 Malaysian, 3 Oriental, 3 Austromalayan

Phymatostetha: 38 Oriental, 25 Malaysian, 1 Palearctic
Cosmoscarta: 78 Oriental, 60 Malaysian, 16 Palearctic, 10 Austromalayan
Ectemnonotum: 34 Malaysian, 5 Oriental
Megastethodon: 26 Austromalayan, 12 Malaysian, 1 Australian
Leptataspis: 63 Malaysian, 38 Oriental, 21 Austromalayan, 2 Palearctic

CLASTOPTERIDAE

Clastoptera: 30 Nearctic, 30 Neotropical, 16 Caribbean

TETTIGELLIDAE (formerly TETTIGONIDAE, TETTIGONIELLIDAE or CICADELLIDAE)

Poeciloscarta: 67 Neotropical, 28 Caribbean
Oncometopia: 51 Neotropical, 21 Caribbean, 13 Nearctic
Aulacizes: 31 Neotropical, 13 Caribbean, 2 Nearctic
Graphocephala: 22 Neotropical, 9 Caribbean, 5 Nearctic

COELIDIIDAE (formerly JASSIDAE)

Laevicephalus: 57 Nearctic, 4 Palearctic, 1 Caribbean
Chlorotettix: 51 Nearctic, 10 Caribbean, 8 Neotropical
Ballana: 66 Nearctic, 2 Caribbean (Pl. 30)

MEMBRACIDAE

Aconophora: 19 Caribbean, 12 Neotropical
Ceresa: 19 Nearctic, 16 Neotropical, 9 Caribbean (Pl. 31)
Cyrtolobus: 36 Nearctic, 2 Caribbean (Pl. 41)
Micrutalis: 13 Caribbean, 10 Neotropical, 6 Nearctic
Enchenopa: 20 Neotropical, 11 Caribbean, 2 Nearctic

The genera with most of their species from one region or contiguous regions, with scattered species from other non-contiguous areas, would not be valid under the present assumptions. Two explanations may be advanced for these. Either they represent genera which have a wide distribution with the intermediate areas poorly surveyed; or they represent genera which are poorly defined and have received species which should not be included. In the majority of cases, I believe the latter is the better explanation. Striking examples of genera that fall in this category are the following:

LARGE GENERA WITH MOST OF SPECIES FROM 1 REGION OR CONTIGUOUS REGIONS PLUS ISOLATED SPECIES

ARAEOPIDAE (formerly DELPHACIDAE)

Ilburnia: 82 Hawaiian Islands, 1 Galapagos Islands, 1 St. Helena Island (Pl. 33)

DICTYOPHARIDAE

Orgerius: 21 Palearctic, 1 Nearctic (Pl. 34)

TIBICINIDAE

Quintilia: 21 Ethiopian, 1 Australian

TOMASPIDAE

Tomaspis: 76 Neotropical, 27 Caribbean, 2 Ethiopian (Pl. 36)
Sphenorhina: 72 Neotropical, 14 Caribbean, 1 Ethiopian (Pl. 33)

CERCOPIDAE

Cercopis: 45 Palearctic, 2 Caribbean, 2 Nearctic, 1 Ethiopian, 1 Oriental

Lastly there are the genera which have, at the present time, a more or less cosmopolitan distribution. Again two ideas may be advanced to account for this wide distribution. Either these are true cosmopolitan genera at the height of their development; or they are an assemblage of species which resemble each other superficially, but not fundamentally. The latter again seems to be the more logical explanation.

If we examine the history of the spread of the horselike animals, they had a nearly world-wide distribution as represented by fossil remains of their close kin; but living species of the genus *Equus* were confined to restricted areas in central Asia and central Africa.

The elephant-like animals spread through the ages from their center of origin in the lower Nile Valley to all regions of the world except Australia. But, the living elephant-like animals are confined to the genus *Elaphas* of the Oriental Region and its close relative *Loxodonta* of Africa.

If this is true of animals of fairly recent origin, it is more than likely true for animals of very ancient origin.

Outstanding examples of so-called cosmopolitan genera are the following:

COSMOPOLITAN GENERA

CIXIIDAE

Andes: 27 Malaysian, 6 Oriental, 1 Austromalayan, 1 Ethiopian

Oliarus: 67 Palearctic, 36 Nearctic, 34 Malaysian, 31 Ethiopian, 22 Oriental, 12 Caribbean, 16 Australian, 9 Oceanic, 4 Neotropical, 1 Austromalayan (Pl. 32)

Myndus: 23 Nearctic, 11 Malaysian, 6 Oceanic, 6 Caribbean, 1 Oriental

Cixius: 62 Palearctic, 18 Nearctic, 18 Neotropical, 9 Ethiopian, 14 Malaysian, 5 Caribbean, 4 Austromalayan, 9 Ethiopian, 3 Australian, 3 Oceanic, 2 Oriental, 2 Maorian

ARAEOPIDAE (formerly DELPHACIDAE)

Ugyops: 14 Malaysian, 9 Oceanic, 6 Austromalayan, 3 Ethiopian, 2 Oriental, 2 Australian, 2 Caribbean, 2 Palearctic

Tropidocephala: 12 Palearctic, 11 Malaysian, 5 Ethiopian, 4 Oriental, 3 Austromalayan, 4 Australian

Perkinsiella: 22 Malaysian, 8 Australian, 8 Austromalayan, 7 Oceanic, 3 Oriental, 2 Palearctic, 1 African

Stenocranus: 22 Palearctic, 6 Nearctic, 6 Malaysian, 1 Australian, 1 Ethiopian, 1 Neotropical, 1 Oceanic

Kelisia: 20 Palearctic, 10 Neotropical, 4 Nearctic, 4 Oceanic, 3 Ethiopian, 1 Malaysian, 1 Oriental

Megamelus: 12 Nearctic, 7 Palearctic, 6 Australian, 4 Neotropical, 3 Malaysian, 1 Oceanic, 1 Austromalayan

Dicranotropis: 13 Palearctic, 11 Ethiopian, 7 Malaysian, 3 Australian, 1 Nearctic, 3 Neotropical, 2 Caribbean, 10 Oceanic

Liburnia: 13 Palearctic, 13 Ethiopian, 9 Neotropical, 7 Australian, 6 Malaysian, 5 Oceanic, 5 Oriental, 4 Nearctic, 4 Caribbean

Delphacodes: 111 Palearctic, 52 Nearctic, 42 Neotropical, 23 Caribbean, 21 Ethiopian, 12 Oriental, 8 Malaysian, 7 Australian, 6 Oceanic, 1 Austromalayan

DERBIDAE

Zoraida: 49 Malaysian, 16 Oriental, 16 Ethiopian, 7 Australian, 5 Palearctic, 5 Austromalayan, 1 Oceanic
Cedusa: 16 Nearctic, 11 Caribbean, 9 Ethiopian, 3 Australian, 2 Palearctic, 2 Neotropical

DICTOPHARIDAE

Dictyophara: 26 Palearctic, 17 Ethiopian, 12 Neotropical, 9 Malaysian, 9 Oriental, 5 Australian, 1 Caribbean

FLATIDAE

Flata: 11 Malaysian, 11 Oriental, 9 Ethiopian, 3 Austromalayan, 2 Palearctic
Lawana: 14 Malaysian, 5 Oriental, 5 Ethiopian, 1 Palearctic, 1 Neotropical
Ormenis: 19 Caribbean, 8 Neotropical, 4 Nearctic, 2 Ethiopian, 1 Oriental
Atracis: 22 Oriental, 18 Malaysian, 9 Caribbean, 16 Palearctic, 8 Ethiopian, 3 Neotropical
Flatoides: 16 Caribbean, 5 Nearctic, 4 Neotropical, 2 Ethiopian, 1 Malaysian

ISSIDAE

Hysteropterum: 76 Palearctic, 8 Nearctic, 6 Caribbean, 2 Australian, 2 Ethiopian, 2 Neotropical, 1 Malaysian (Pl. 35)
Issus: 18 Palearctic, 5 Malaysian, 1 Nearctic, 1 Caribbean, 1 Australian

RICANIIDAE

Pochazia: 17 Malaysian, 14 Oriental, 6 Ethiopian, 4 Palearctic, 1 Austromalayan
Ricania: 25 Malaysian, 16 Oriental, 13 Ethiopian, 12 Austromalayan, 11 Palearctic, 11 Australian (Pl. 38)
Ricanula: 12 Austromalayan, 12 Malaysian, 7 Ethiopian, 5 Oriental, 2 Palearctic, 1 Neotropical

CICADIDAE

Platypleura: 29 Ethiopian, 17 Palearctic, 20 Oriental, 4 Malaysian, 1 Australian, 1 Oceanic
Chremistica: 11 Malaysian, 7 Oriental, 6 Palearctic, 4 Ethiopian
Tibicen: 46 Nearctic, 17 Palearctic, 4 Caribbean, 2 Neotropical, 2 Oceanic, 1 Oriental, 1 Ethiopian, 1 Malaysian

TIBICINIDAE

Cicadetta: 61 Australian, 38 Palearctic, 29 Oriental, 8 Ethiopian, 7 Austromalayan, 4 Nearctic, 1 Malaysian, 1 Neotropical, 1 Oceanic

TOMASPIDAE

Triecphora: 25 Ethiopian, 9 Palearctic, 8 Neotropical (Pl. 40)
Aufidus: 21 Austromalayan, 13 Malaysian, 5 Oriental, 3 Australian, 2 Oceanic, 1 Palearctic

CERCOPIDAE

Ptyelus: 22 Ethiopian, 14 Oriental, 11 Austromalayan, 5 Palearctic, 1 Maorian
Clovia: 67 Malaysian, 49 Austromalayan, 34 Ethiopian, 17 Oriental, 6 Palearctic, 6 Australian (Pl. 34)
Aphrophora: 70 Palearctic, 11 Nearctic, 11 Oriental, 4 Neotropical, 4 Caribbean, 1 Ethiopian
Philagra: 16 Palearctic, 7 Oriental, 3 Malaysian, 4 Australian
Cercopis: 45 Palearctic, 1 Oriental, 2 Caribbean, 1 Ethiopian, 2 Nearctic

TETTIGELLIDAE (formerly TETTIGONIDAE, TETTIGONIELLIDAE or CICADELLIDAE)

Tettigella (formerly *Cicadella* or *Tettigonia*): 238 Neotropical, 69 Caribbean, 52 Oriental, 53 Malaysian, 40 Palearctic, 35 Ethiopian, 10 Austromalayan, 6 Nearctic, 1 Oceanic

Kolla: 20 Oriental, 9 Malaysian, 4 Nearctic, 3 Palearctic, 3 Ethiopian, 3 Caribbean, 3 Neotropical, 1 Australian

GYPONIDAE

Gypona: 112 Neotropical, 41 Caribbean, 7 Nearctic, 1 Oriental, 1 Australian
Penthimia: 21 Oriental, 12 Malaysian, 8 Ethiopian, 8 Palearctic, 3 Neotropical, 2 Nearctic, 1 Australian, 1 Austromalayan

LEDRIDAE

Ledra: 13 Oriental, 13 Malaysian, 8 Australian, 6 Palearctic, 1 Neotropical
Petalocephala: 27 Oriental, 12 Palearctic, 9 Malaysian, 7 Ethiopian, 2 Austromalayan, 2 Australian

COELIDIIDAE (formerly JASSIDAE)

Xestocephalus: 15 Nearctic, 8 Palearctic, 8 Caribbean, 6 Oriental, 5 Neotropical, 5 Malaysian, 4 Oceanic, 2 Australian, 1 Austromalayan
Selenocephalus: 18 Ethiopian, 6 Palearctic, 4 Oriental, 2 Malaysian, 2 Austromalayan
Hecalus: 9 Palearctic, 7 Malaysian, 6 Ethiopian, 5 Oriental, 4 Nearctic, 1 Neotropical, 1 Australian
Parabolocratus: 15 Nearctic, 13 Palearctic, 4 Oriental, 4 Ethiopian, 3 Malaysian, 1 Neotropical
Scaphoideus: 49 Nearctic, 18 Oriental, 10 Palearctic, 8 Neotropical, 5 Ethiopian, 2 Caribbean, 1 Malaysian, 1 Australian
Platymetopius: 23 Palearctic, 5 Neotropical, 3 Caribbean, 2 Nearctic, 1 Oriental
Deltocephalus: 172 Palearctic, 42 Nearctic, 24 Oriental, 19 Caribbean, 15 Neotropical, 5 Ethiopian, 4 Australian, 3 Malaysian
Euscelis: 20 Palearctic, 11 Nearctic, 4 Caribbean, 4 Neotropical, 5 Oriental, 4 Australian, 1 Ethiopian
Athysanus: 100 Palearctic, 17 Neotropical, 6 Nearctic, 5 Ethiopian, 3 Caribbean, 3 Oriental
Eutettix: 13 Nearctic, 12 Neotropical, 6 Oriental, 6 Malaysian, 5 Palearctic, 4 Ethiopian, 3 Australian, 1 Oceanic
Phlepsius: 70 Nearctic, 13 Neotropical, 10 Palearctic, 8 Caribbean, 6 Ethiopian, 2 Oriental
Thamnotettix: 104 Palearctic, 35 Nearctic, 23 Neotropical, 11 Ethiopian, 6 Caribbean, 4 Oriental, 4 Malaysian, 2 Oceanic
Coelidia: 71 Neotropical, 31 Palearctic, 25 Oriental, 7 Caribbean, 5 Nearctic, 31 Malaysian, 13 Ethiopian, 11 Austromalayan
Balclutha: 26 Palearctic, 7 Oriental, 7 Caribbean, 7 Nearctic, 2 Neotropical, 6 Ethiopian, 4 Malaysian, 1 Austromalayan
Cicadula: 28 Palearctic, 4 Oceanic, 2 Nearctic, 2 Caribbean, 2 Oriental, 1 Neotropical, 1 Malaysian, 1 Australian, 1 Ethiopian

IASSIDAE (formerly BYTHOSCOPIDAE)

Macropsis: 47 Palearctic, 32 Nearctic, 12 Ethiopian, 11 Australian, 8 Malaysian, 3 Oriental, 1 Caribbean
Agallia: 28 Palearctic, 24 Caribbean, 19 Neotropical, 10 Nearctic, 5 Oriental, 2 Ethiopian, 1 Oceanic
Iassus (formerly *Bythoscopus*)*:* 17 Palearctic, 16 Neotropical, 6 Oriental, 6 Oceanic, 6 Australian, 5 Malaysian, 5 Ethiopian, 2 Caribbean, 1 Nearctic
Idiocerus: 70 Palearctic, 40 Nearctic, 29 Neotropical, 17 Australian, 6 Oriental, 4 Ethiopian, 2 Caribbean, 2 Malaysian, 1 Oceanic

CICADELLIDAE (formerly EUPTERYGIDAE or TYPHLOCYBIDAE)

Dikraneura: 36 Nearctic, 14 Palearctic, 13 Neotropical, 11 Caribbean, 2 Australian, 1 Maorian

Empoasca: 102 Nearctic, 51 Palearctic, 21 Oriental, 19 Caribbean, 10 Neotropical, 4 Ethiopian, 3 Malaysian, 1 Australian, 1 Oceanic
Cicadella: 37 Palearctic, 9 Nearctic, 5 Oriental, 1 Australian
Typhlocyba: 60 Nearctic, 52 Palearctic, 20 Oriental, 7 Neotropical, 4 Caribbean, 3 Australian, 1 Ethiopian, 1 Malaysian, 1 Maorian
Erythroneura: 314 Nearctic, 50 Palearctic, 15 Oriental, 6 Australian, 5 Neotropical, 5 Ethiopian, 5 Oceanic, 3 Malaysian

MEMBRACIDAE

Leptocentrus: 21 Ethiopian, 13 Oriental, 10 Malaysian, 3 Palearctic, 1 Austromalayan, 1 Australian
Gargara: 54 Malaysian, 34 Oriental, 32 Palearctic, 11 Ethiopian
Tricentrus: 38 Palearctic, 36 Malaysian, 23 Oriental, 2 Austromalayan, 1 Australian
Centrotus: 13 Ethiopian, 8 Oriental, 8 Malaysian, 3 Palearctic, 3 Austromalayan, 1 Nearctic, 1 Caribbean

These two groups of genera, which are cosmopolitan or have isolated species, and are perhaps not true phylogenetic groups, constitute about one sixth of the known genera. They should be checked from every known standpoint to determine their true status. Until further evidence can be produced, I am holding them as invalid genera, and I trust that every student of the order will do his utmost to clear up these uncertainties.

Let us consider for a moment the implications in assuming that the study of zoogeographic distribution will give us characters for defining taxonomic units just as the study of morphology does. If we accept the theory of the center of origin for taxonomic groups and if we accept the evolution of groups higher than the species, then it seems to me to be perfectly obvious that as groups spread from their centers they will of necessity diverge. And, normally, the greater the spread the greater the divergence. Somewhere in this spread the group will cross a zoogeographic boundary and somewhere this group will diverge until it can no longer be included within the original group taxonomically. Tentatively the zoogeographic boundary may be set at the biotic province for the species and at the region for the genus.

This gives us then a standard other than the morphological characteristic to measure these two taxonomic units. This places in the hands of the taxonomists a new criterion for judging genera and species. And, on the other hand, it makes it possible for the zoogeographer to define regions and biotic provinces with increased exactitude.

The limitations of this method are fully realized. Species may be rapidly and widely distributed by commerce. The case of the corn plant hopper and certain other pests have already been alluded to. Many others have been recorded by science. This, however, does not alter the laws of nature. Many genera also may include species endowed with wide powers of adaptation so that they may thrive over long periods of time and their characters may be so fixed that they remain stable. Thus we may have genera that are distributed over several zoogeographic regions. But these cases are the exception, in my opinion. Then, we may have genera that represent that phase in distribution

where the species are represented only in isolated areas of favorable combinations of ecological factors in a world-wide distribution. In these cases we may have isolated species in widely separated regions which are truly representatives of an old and stable genus. But if such a group is old enough to have spread from its center to far distant areas of the world, the chances are that it is so old that evolution has had a chance to get in its deadly work and these isolated species no longer belong to the same genus but to closely related genera. Then we may have cases of genera which are at their zenith and are truly represented by species of world-wide distribution.

If this concept be accepted, it makes it possible to restudy genera not only from the standpoint of new morphological characters, but to test our definitions of various genera by the standard of zoogeographic regions. Thus it might be possible for us to arrive at a closer approximation of the truth, the goal of all science.

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EXPLANATION OF PLATES

PLATE 23

Dispersal of the horse-like animals from a hypothetical center in western North America. The present distribution of wild horses, asses and zebras is indicated by the heavy shading. Each animal has a scale indicating its height in feet and a geological column indicating its distribution in time by black. 1. A four-three toed horse, *Eohippus*. 2. A four-three toed horse, *Orohippus*. 3. A three-toed horse, *Mesohippus*. 4. A three-toed horse, *Merychippus*. 5. A three-toed horse, *Neohipparion*. 6. A one-toed horse, *Pliohippus*. 7. The true horse, *Equus*. 8. The Asiatic wild horse, *Equus* sp. 9. The wild ass, *Equus* sp. 10. A zebra, *Equus* sp. 11. A one-toed horse, *Hippidion*.

PLATE 24

The phylogeny and dispersal of the elephant-like animals from a hypothetical center in northern Africa. The present distribution of elephants is indicated by the heavy shading. Each animal has a scale indicating its height in feet and a geological column indicating its distribution in time by black. 1. A mastodon, *Gomphotherium*. 2. A four-tusked mastodon, *Triphodon*. 3. The Columbian elephant, *Parelephas*. 4. A serrate-toothed mastodon, *Serridentinus*. 5. The woolly mammoth, *Mammonteus*. 6. A mammoth, *Stegodon*. 7. The Indian elephant, *Elephas*. 8. A long-jawed mastodont, *Dinotherium*. 9. A long-jawed mastodont, *Phiomia*. 10. An amphibious mastodont, *Moeritherium*. 11. A long-jawed mastodon, *Palaeomastodon*. 12. A true mastodon, *Mastodon*. 13. The African elephant, *Loxodonta*.

PLATE 25

The dispersal of the starling from the time of its introduction in New York in 1890. Based on Goode's Base Map No. 9 by permission of The University of Chicago Press.

PLATE 26

The dispersal of the boll weevil from the time of its introduction in Texas in 1892. The dotted line indicates the approximate northern limit of the growth of cotton. Based on Goode's Base Map No. 9 by permission of The University of Chicago Press.

PLATE 27

The zoogeographic map of the world based on a study of the distribution of genera and species of Homoptera. Solid lines indicate the approximate boundaries of regions. Dotted lines of subregions. Solid black indicates areas with indefinite boundaries. New regions proposed are as follows: Caribbean, including Mexico, Central America and West Indies; Malaysian, including the East Indies and the Philippines; Austromalayan, including New Guinea and Melanesia; and Maorian, with New Zealand and the adjacent islands. Based on Goode's Base Map No. 101M by permission of the University of Chicago Press.

PLATE 28

Known distribution of the corn plant hopper, *Peregrinus maidis* Ashmead, indicated by crosshatched areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 29

The distribution of the species of the genus *Tragopa*, indicated by the crosshatched areas. Known distribution of species of the Family MACHAEROTIDAE, indicated by the stippled areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 30

Distribution of the species of the genus *Lallemandana*, indicated by the stippled areas. Distribution of the species of the genus *Ballana*, indicated by vertically lined areas. Distribution of the species of the Subfamily TETTIGOMETRINAE, indicated by the crosshatched areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 31

Distribution of the species of the Subfamily EGROPINAE, indicated by the vertically lined areas. Distribution of the species of the genus *Ceresa*, indicated by the stippled areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 32

Distribution of the species of the genus *Oliarus*, indicated by the vertically lined areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 33

Distribution of the species of the genus *Ilburnia*, indicated by the crosshatched areas. Distribution of the species of the genus *Sphenorhina*, indicated by the stippled areas. Distribution of the species of the genus *Sextius*, indicated by the vertically lined areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 34

Distribution of the species of the genus *Orgerius*, indicated by the crosshatched areas. Distribution of the species of the genus *Clovia*, indicated by the stippled areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 35

Distribution of the species of the genus *Hysteropterum*, indicated by the stippled areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 36

Distribution of the species of the genus *Tomaspis*, indicated by crosshatched areas. Distribution of the species of the genus *Hemisphaerius*, indicated by the stippled areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 37

Distribution of the species of the genus *Thionia*, indicated by the vertically lined areas. Based on Goode's Base No. 101M by permission of The University of Chicago Press.

PLATE 38

Distribution of the species of the genus *Monecphora*, indicated by the stippled areas. Distribution of the species of the genus *Ricania*, indicated by the vertically lined areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 39

Distribution of the species of the genus *Laccogrypota*, indicated by the vertically lined areas. Distribution of the species of the genus *Locris*, indicated by the stippled areas. Distribution of the species of the genus *Callitettix*, indicated by the crosshatched areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 40

Distribution of the species of the genus *Triecphora*, indicated by the stippled areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 41

Distribution of the species of the genus *Cyrtolobus*, indicated by the vertically lined areas. Distribution of the oaks of the genus *Quercus*, upon which most of the species of the genus *Cyrtolobus* feed, is shown by the stippled areas. Based on Goode's Base Map No. 101M by permission of The University of Chicago Press.

PLATE 23

RECENT
PLEISTOCENE
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
1 Ft.
2 Ft. 6 In.
1 Ft. 6 In.
3 Ft. 4 In.
3 Ft. 4 In.
3 Ft. 4 In.
4 Ft.
4 Ft. 6 In.
4 Ft.
4 Ft. 1 In.
1
2
3
4
5
6
7
8
9
10
11

PLATE 24

RECENT
PLEISTOCENE
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
1
2
3
4
5
6
7
8
9
10
11
12
13
14

PLATE 25

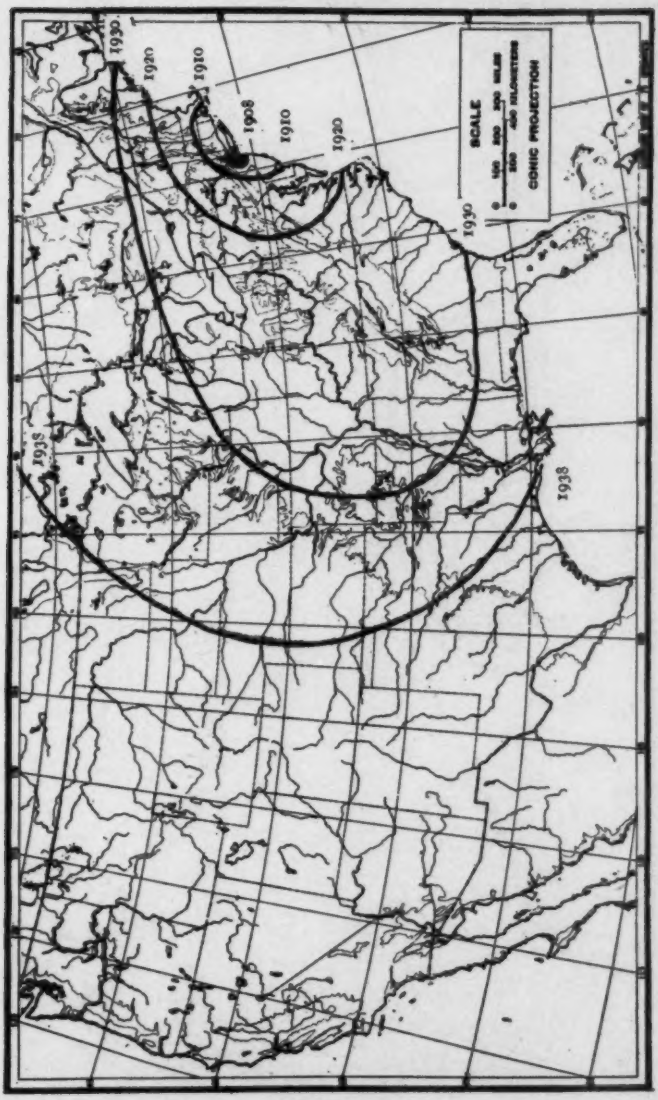
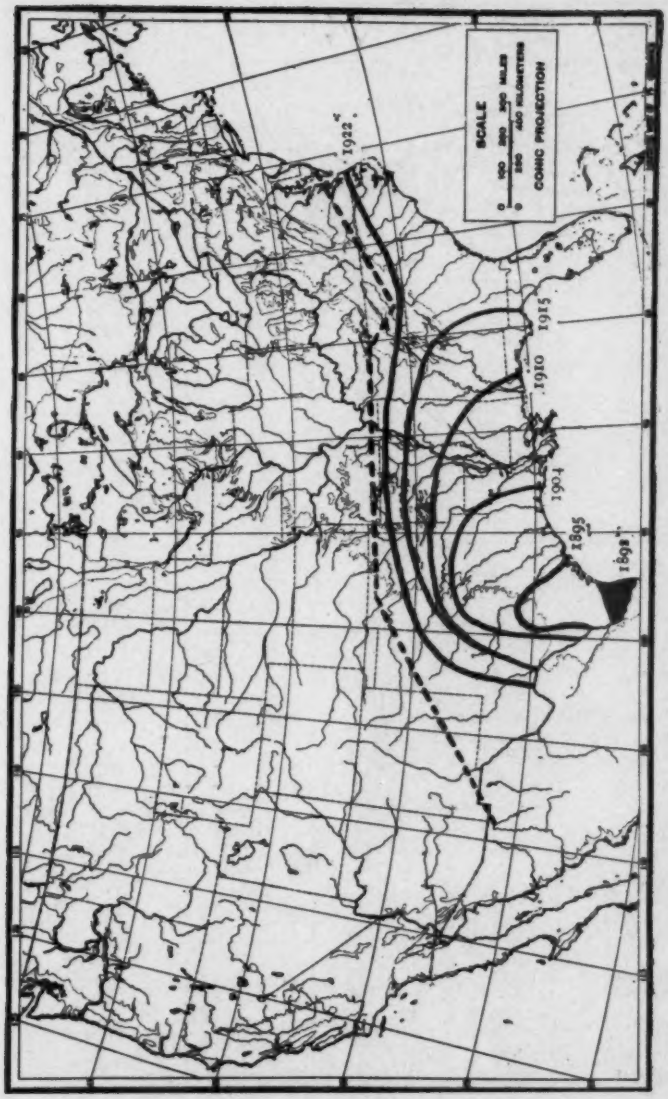

1930
1920
1910
1908
1910
1920
1930
1938
1938
SCALE
CONIC PROJECTION

PLATE 26


SCALE
0 100 200 300 MILES
0 200 400 KILOMETERS
CONIC PROJECTION
1922
1915
1910
1904
1895
1891

WORLD, MERCATOR

No. 101M

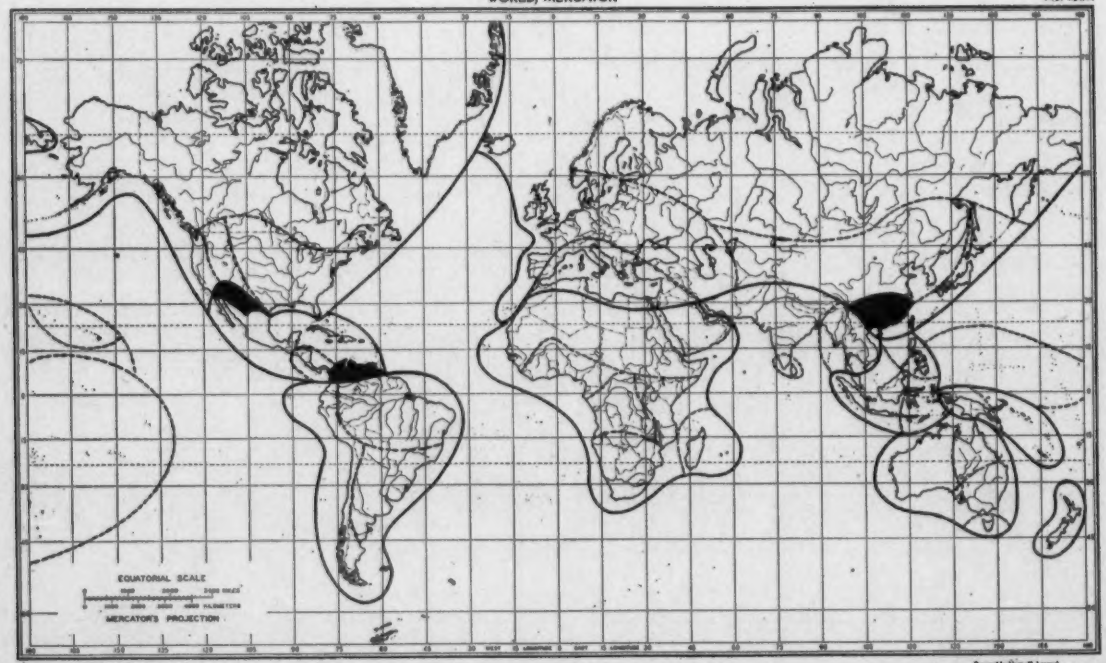


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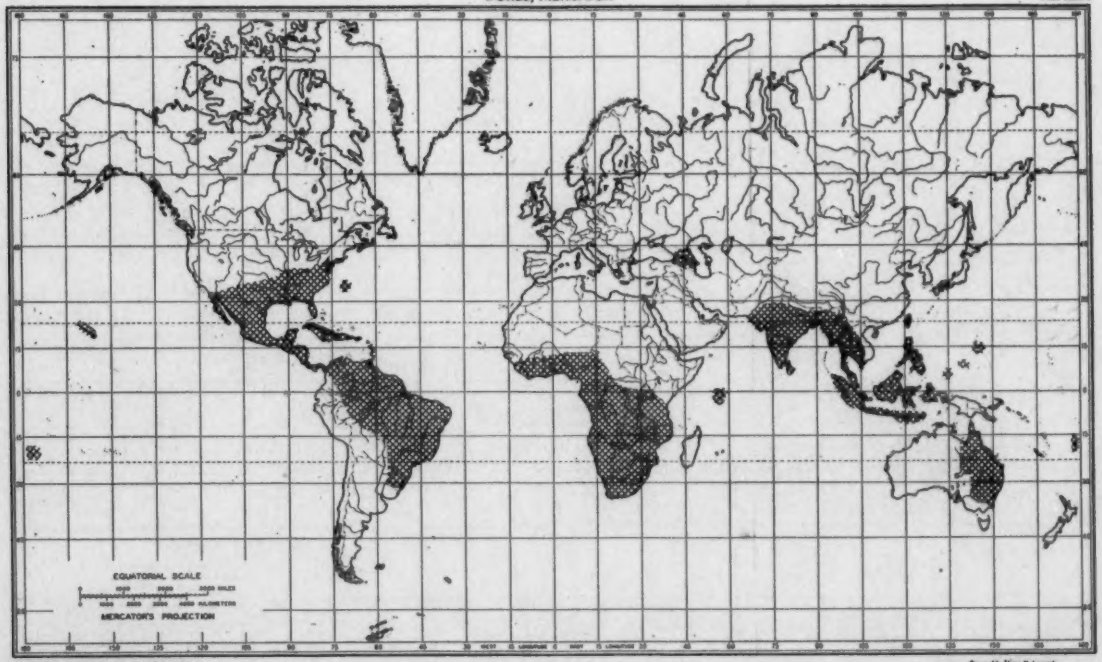
PLATE 27

WORLD, MERCATOR

No. 101M



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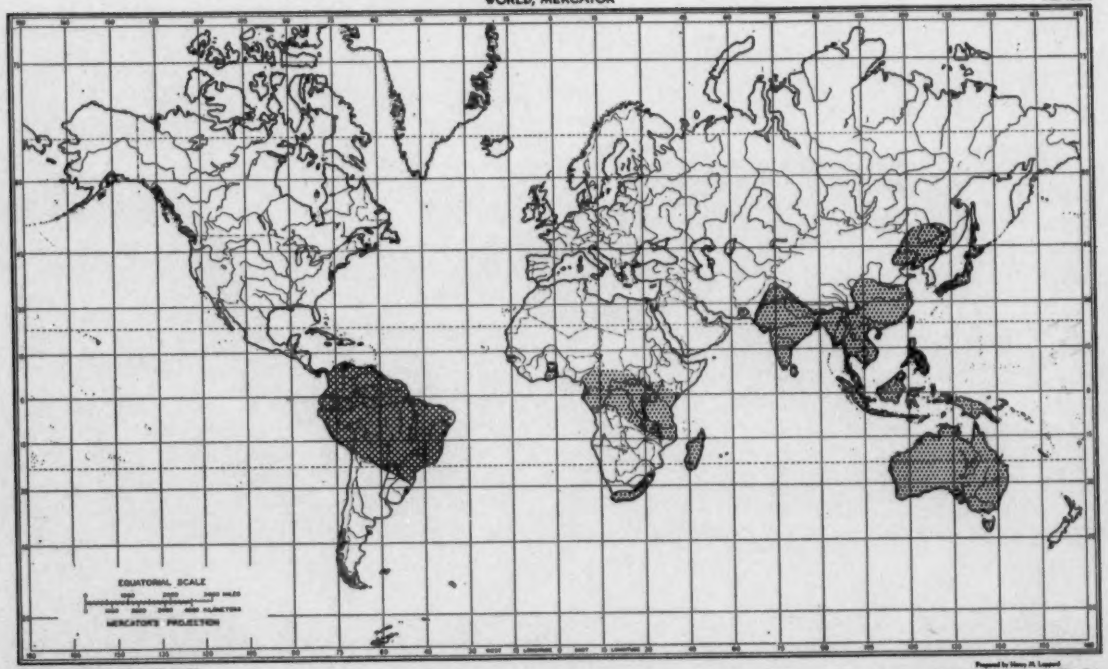

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PLATE 29

WORLD, MERCATOR

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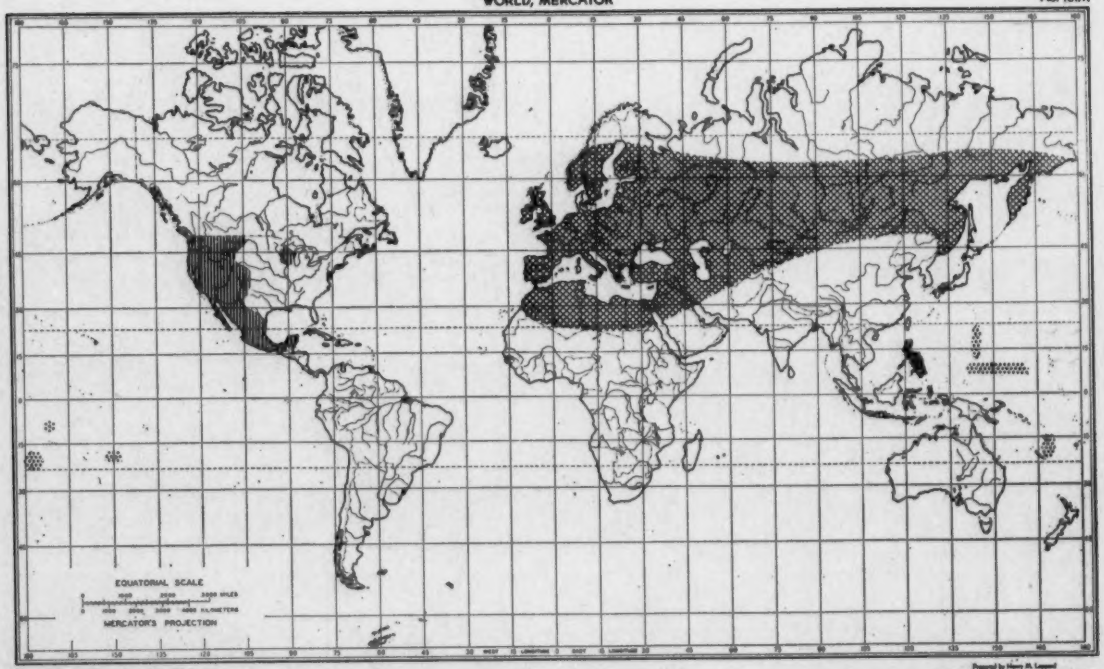

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PLATE 30

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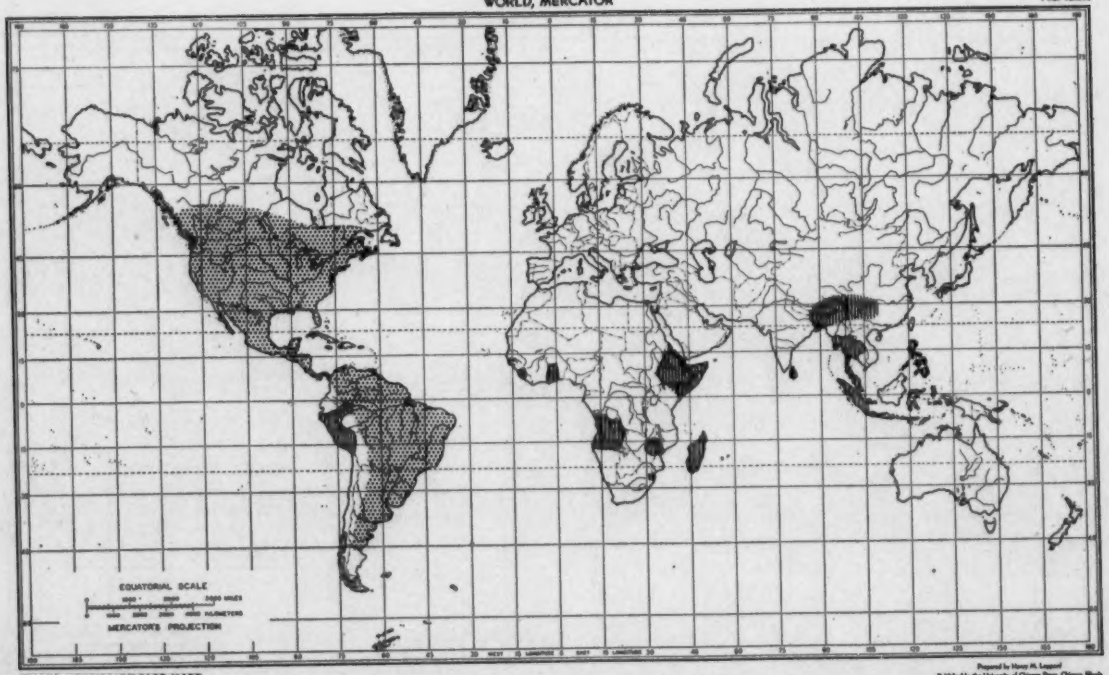

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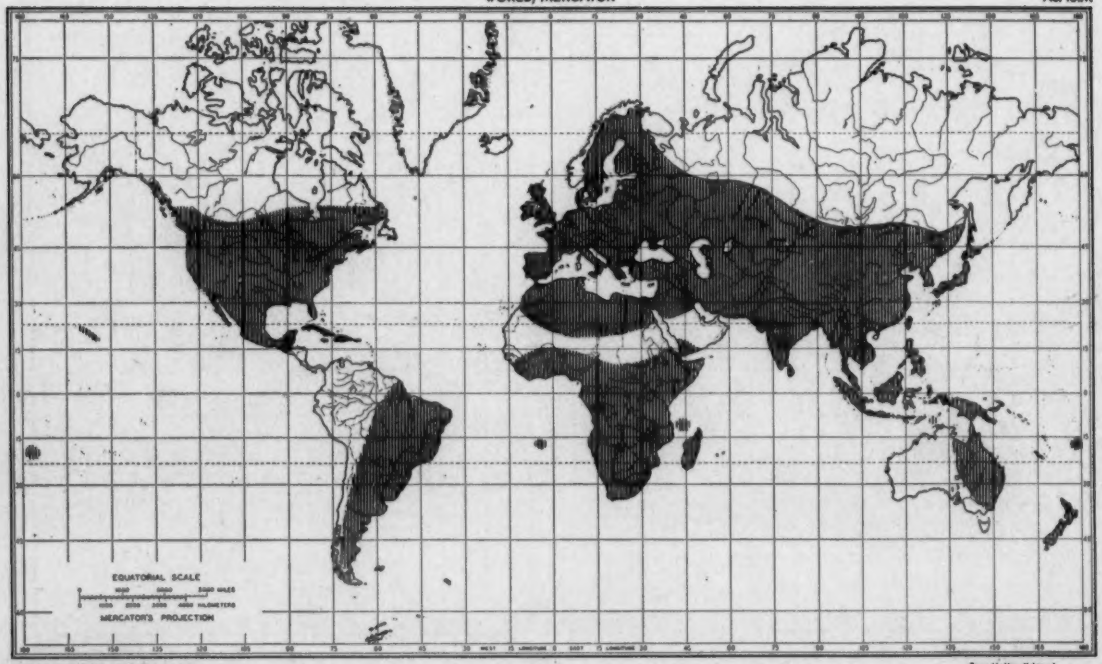

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PLATE 32

PLATE 33

No. 10HA
WORLD, MERCATOR
EQUATORIAL SCALE
MERCATOR'S PROJECTION
GOODE'S SERIES OF BASE MAPS

PLATE 34

No. 101M
WORLD, MERCATOR
EQUATORIAL SCALE
MERCATOR'S PROJECTION
GOODE'S SERIES OF BASE MAPS

WORLD, MERCATOR

No. 101M

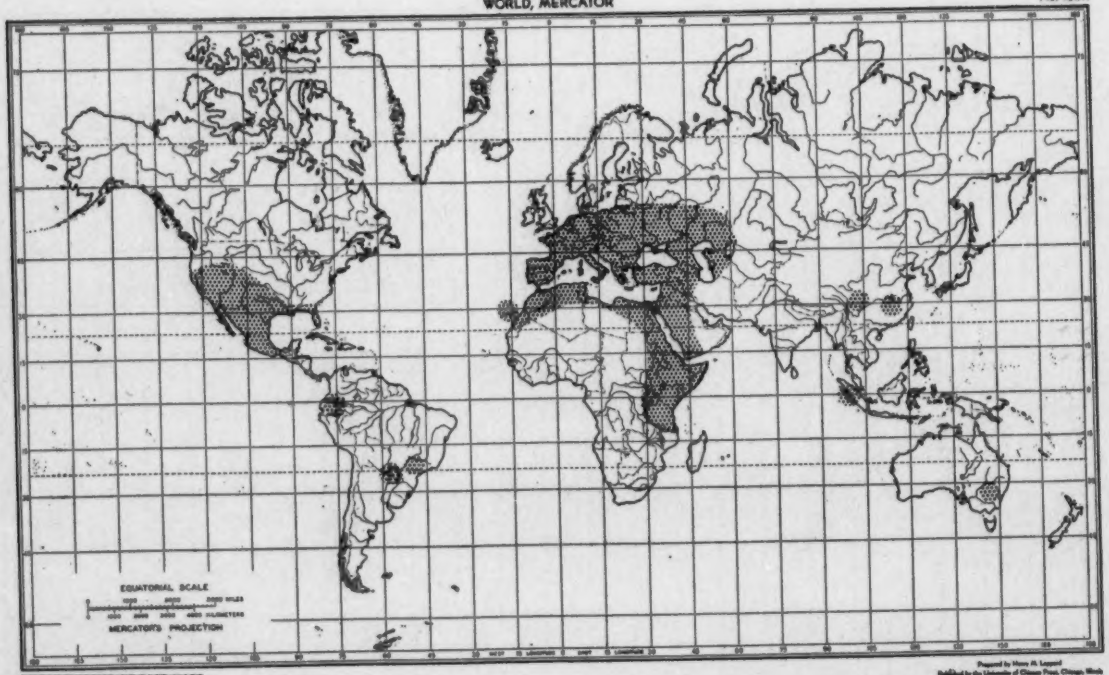

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PLATE 35

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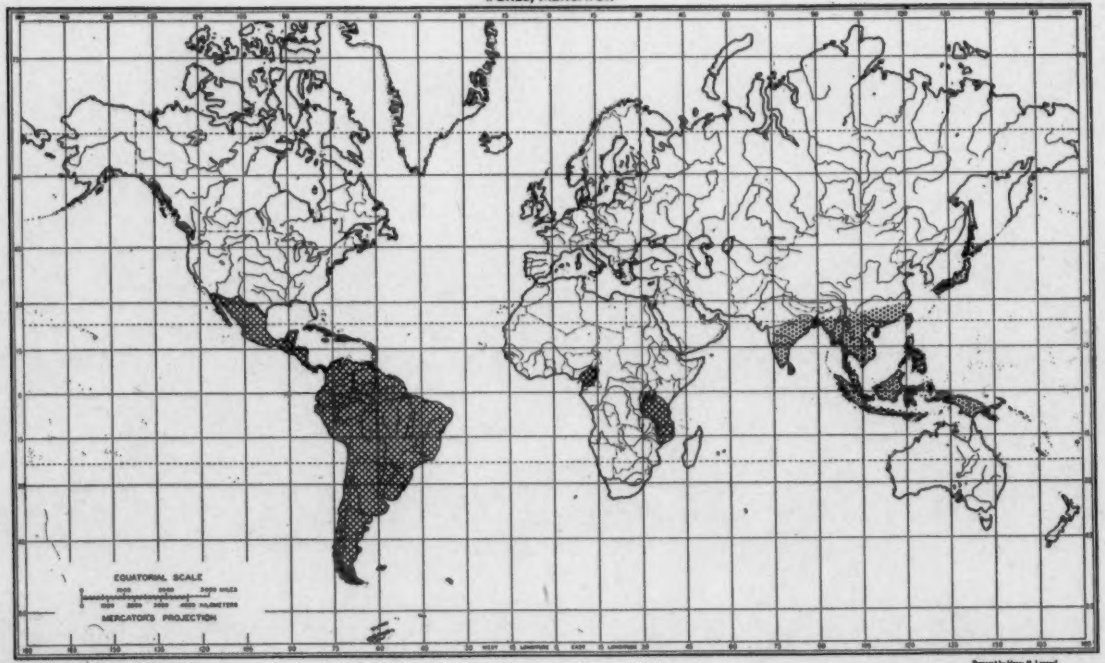

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PLATE 36

PLATE 37

WORLD, MERCATOR
No. 20W
EQUATORIAL SCALE
MERCATOR'S PROJECTION
GOODE'S SERIES OF BASE MAPS

WORLD, MERCATOR

No. 101M

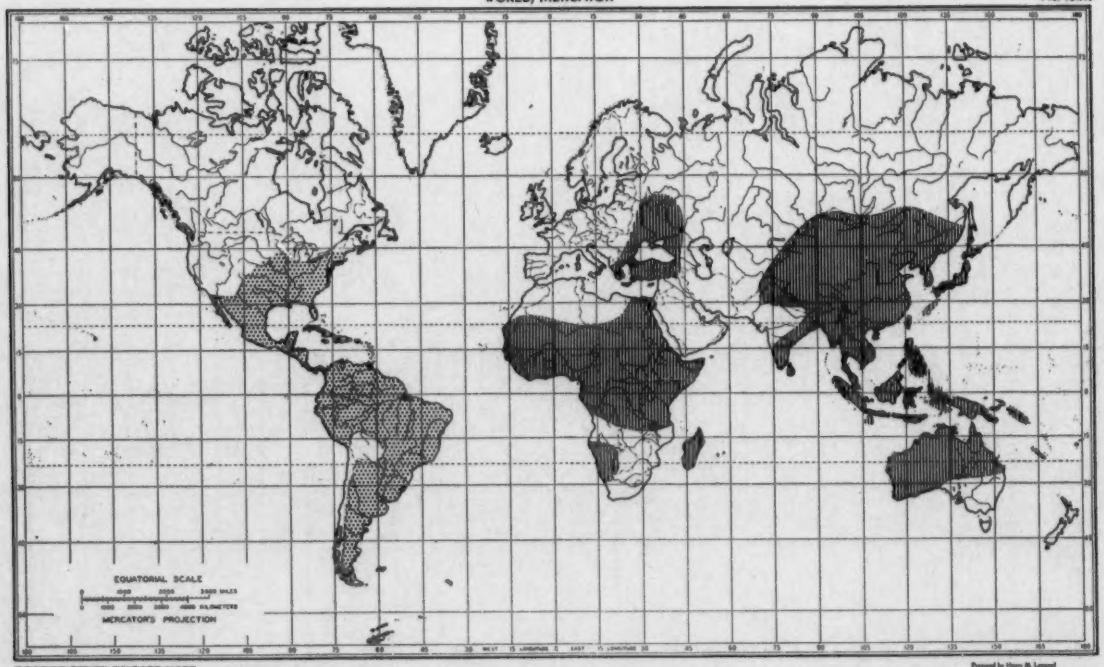

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PLATE 38

WORLD, MERCATOR

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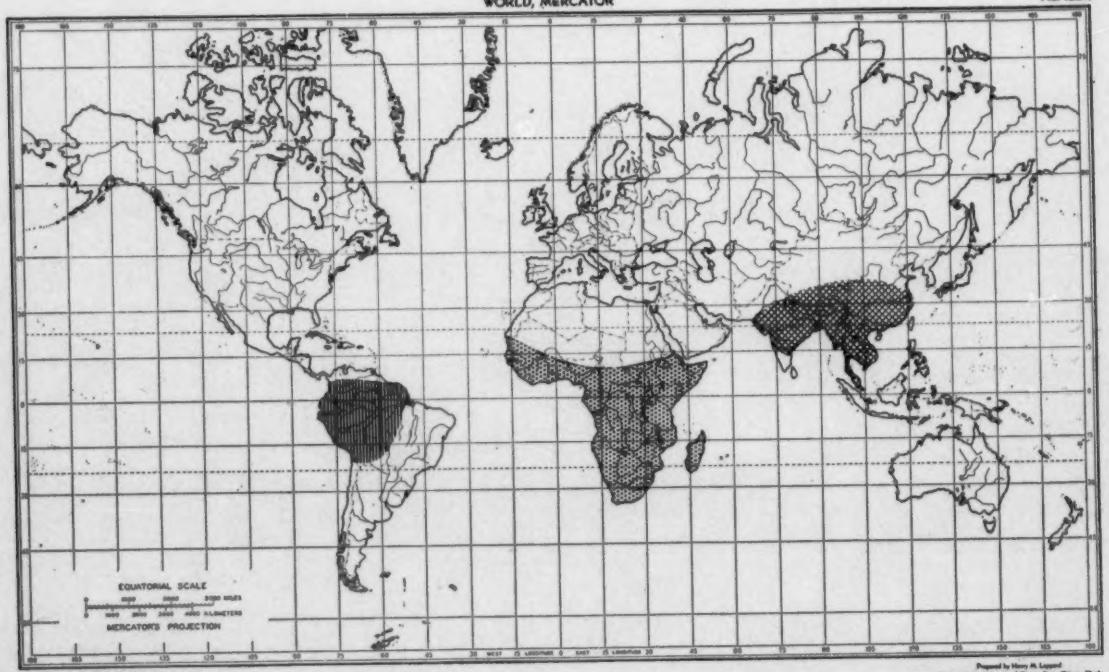

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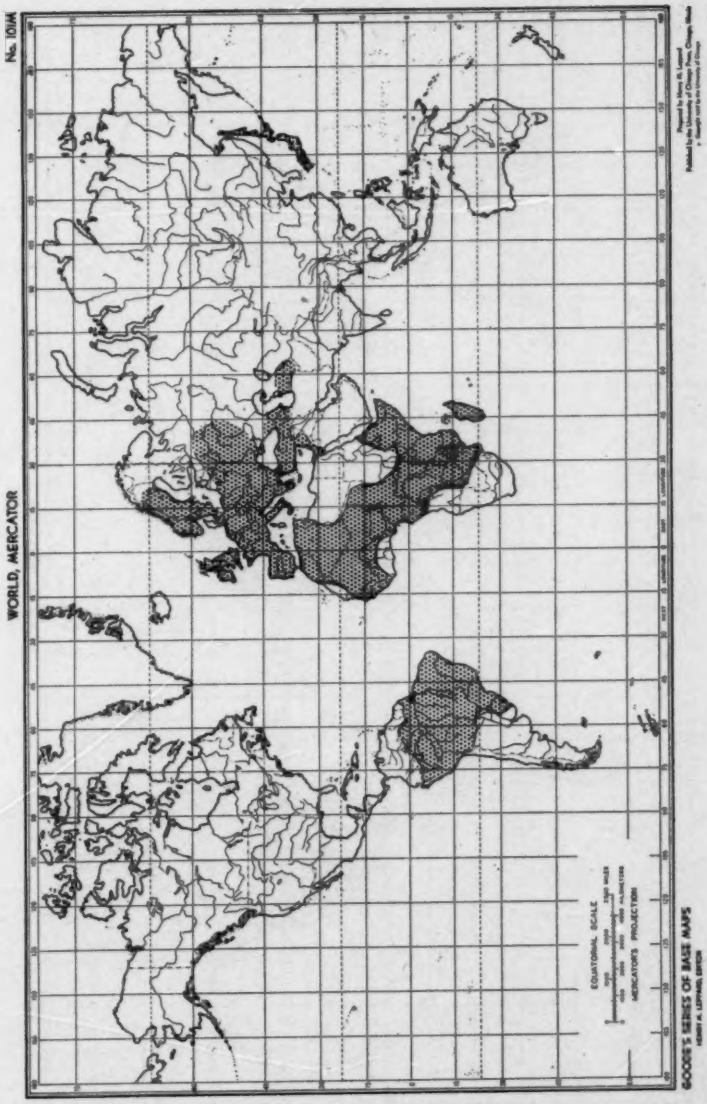
PLATE 39

PLATE 40


No. 10(H)
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MERCATOR'S PROJECTION
GOODE'S SERIES OF BASE MAPS

WORLD, MERCATOR

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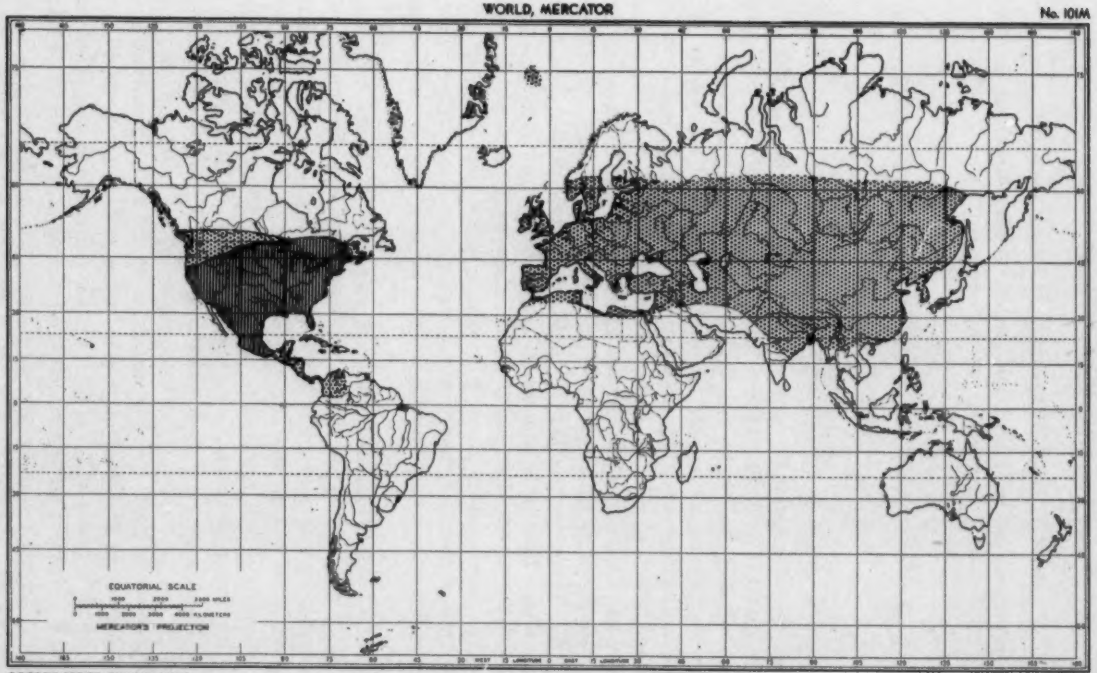

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PLATE 41

NEW AND UNUSUAL DARK-SPORED AGARICS FROM NORTH AMERICA

By Alexander H. Smith and L. R. Hesler

Papers from the Department of Botany and the Herbarium, University of Michigan, Ann Arbor, Michigan

and

Contribution from the Botanical Laboratory, N. Ser. No. 90, University of Tennessee, Knoxville, Tennessee

Four Text Figures

During the past ten years we have made a large number of collections of fungi in the dark-spored group of agarics, but their classification has been, in general, both a slow and exceedingly tedious task. The group as a whole has never been critically revised for North America on the basis of the microscopic characters now accepted as fundamental in agarics, and the literature on the Europen species also has been sadly deficient in the same respect. In the past most authors have adhered rather strictly to the Friesian system of classification and thus maintained a series of genera which, in the light of studies on the anatomy of the fruiting body, now appear to be both illogical and unusable. The lack of carefully ascertained generic concepts on the one hand, and vague species descriptions on the other have made it next to impossible to use most of the literature for the purpose for which it exists. Even for species whose names appear commonly in the literature, we find many instances in which more than one fungus has been referred to under a single binomial, as, for instance, in *Coprinus domesticus*.

In other groups of agarics where a similar situation existed in the past the difficulties have been gradually overcome by more critical studies of the fungi as they occur in nature and by the publishing of more accurate descriptions of them. This process is now being applied to the dark-spored agarics in Europe, particularly by such mycologists as Kühner, Josserand and Romagnesi, and we believe that a similar approach applied to the American species will hasten a better understanding of the group as a whole and allow comparisons of American and European species to be made more accurately.

The generic concepts we have employed here are, with minor exceptions, in line with those of the modern school of taxonomists, and have been best summarized in Singer's classification of the gill fungi. The limits of the genera as we recognize them are in most instances broader than those of other authors, but the groupings are essentially the same. For instance, we include *Deconica* in *Psilocybe*. These are the concepts which will be found in the senior author's revision of the dark-spored agarics for the North American Flora. They will be discussed in detail at a later date.

In the following account three species of *Coprinus* are treated, two of which

are described as new. Six species of *Psathyrella* are included, five of which are new, and two new species of *Pseudocoprinus* are also described. Seven species are described in *Psilocybe*, making a total of eighteen species treated. The collections came from various places in North America from Nova Scotia to Washington south to Southern California in the West and Alabama in the East.

Coprinus Burkii Smith sp. nov. Fig. 1; A, B.

Pileus 0.3–0.6 cm. altus, conicus demum late conicus, circa 6 mm. latus, subsquamosus, glabrescens, lacteus vel cremicolor, sulcato-striatus; lamellae confertae, angustae, liberae; stipes 1–2 cm. longus, 0.5 mm. crassus, aequalis vel sursum attenuatus, ad basim volvato-zonatus; sporae 5.5–6.3 x (3) 3.8–4.2 x 4.5–5.3 μ; pleurocystidia cylindrica, 10–15 μ diam.

Pileus 0.3–0.6 cm. high and obtusely conic in button stages, when expanded broadly conic and then about 6 mm. broad and up to 12 mm. high, surface at first covered by superficial patches of pallid interwoven threads of universal veil tissue, veil remnants soon evanescent or remaining on or around the disc, surface pallid to milky white over marginal area, cream color over disc, becoming sulcate-striate in drying but not plicate-striate; *flesh* very delicate, odor and taste not recorded; *lamellae* close, narrow, free, connected by voluminous pleurocystidia, pallid when young, cocoa-brown from the spores; *stipe* 1–2 cm. long, 0.5 mm. thick, equal or slightly enlarged at the base, white, with a volva-like zone of veil remnants at base, fibrillose to pruinose upward, attached to substratum by a mycelioid mat.

Spores pale cocoa-color when first revived in KOH but finally pale fuscous, 5.5–6.3 x (3) 3.8–4.2 x 4.5–5.3 μ, somewhat flattened, subspheric to broadly ovate in face view, broadly ovate to slightly inequilateral in side view, the pore apical but very inconspicuous; *basidia* 12–16 x 6–7 μ, trimorphic, hyaline in KOH; *paraphyses* coprinoid; pleurocystidia abundant, cylindric, 10–15 μ in diam. (but not reviving well), extending across the gill cavity; *cheilocystidia* none seen (apparently all had collapsed); *gill trama* hyaline in KOH; pileus trama hyaline in KOH, cuticle of enlarged cells (but not distinctly vesiculose); *veil remnants* of hyaline contorted hyphae with numerous short rodlike projections or spines and thickened walls at least in the main trunk (similar to those of *C. phaeosporus* although hyaline).

Habit, habitat and distribution: Scattered on fern petioles near Birmingham, Ala. June 1942, R. P. Burke (EO).

Discussion: This is an interesting though minute species of *Coprinus* readily distinguished by its habitat on fern petioles, the thick-walled spiny hyphae making up the veil tissue, and the small flattened spores. It is closely related to *C. rotundisporus* in its spore characters, but differs in type of veil hyphae, habitat, and smaller spores. I have a number of collections of other Coprini from different habitats all with the same general appearance of *C. Burkii* but differing in veil characters (lacking spinose hyphae), and having larger spores. Some occurred on grass culms or were consistently found on ashes where brush had been burned within the year. All of these have the same broad spores as seen in face view, but in all the measurements are larger than for *C. Burkii*. These collections will be reported upon later. Hanna (Mycologia, 1939: 256) describes *C. urticicola* as having somewhat similar spinose hyphae composing the tissue of

the veil but it is a much larger fungus (caps 1–3 cm. broad) and his photomicrographs *F* & *G* clearly show spores of a different shape. Lange describes the branched hyphae of the veil as thick-walled and light brown for *C. phaeosporus*, a species Hanna considers synonymous with *C. urticicola*. *Coprinus Friesii* sensu Lange and *C. pallidisporus* Lange both have larger spores, and in *C. microspermus* Lange the spores are apparently not flattened and in addition the branched hyphae of the veil are brown. The habitat of *C. Burkii* s unique, but for these small velose species it is impossible yet to evaluate properly the differences in habitat as a taxonomic character. A larger series of collections needs to be studied.

COPRINUS DOMESTICUS Fr. sensu Lange

Pileus 1.5–2.5 cm. high, 3–5 cm. broad when fully expanded, obtusely conic becoming convex to nearly plane, surface at first covered by a conspicuous universal veil which is fibrillose over the exterior and composed of brown-walled hyphae but next to the cap the tissue is white, subgranulose and breaks up to form areolate small warts, the warts usually with a conic tuft of brown fibrils, scales numerous until near maturity, color of cap-surface pale to dark ochraceous tawny, radially wrinkled young, sulcate striate in age and finally splitting; *flesh brown*, thin, very fragile, odor and taste not distinctive; *lamellae* white, broad (6 mm.), crowded, attached to apex of stipe, pruinose under a lens from cystidia; *stipe* 4–7 cm. long, 3–6 mm. thick, white, fragile, hollow, pruinose-pubescent from cystidia above line left by broken veil, the bulbous base almost marginate and veil usualy breaking along the rim but occasionally at the lower third if stipe is clavate, and then with scattered brownish fibrils over the basal portion, a conspicuous brown ozonium surrounding the base and penetrating under the bark when carpophores are produced more or less out in the open.

Spores blackish in deposits, 7–8.6 x 3.7–4.2 μ, not appreciably flattened, elliptic to oblong in face view, slightly bean-shaped in side view, pore apical; *basidia* 14–21 x 6–7 μ, trimorphic, four-spored; *paraphyses* coprinoid, 10–12 μ in diam.; pleurocystidia abundant, vesiculose to ellipsoid or narrowed to the rounded apex, (32) 80–130 x (14) 20–50 μ, readily collapsing; *cheilocystidia* vesiculose, readily collapsing, 12–20 μ in diam.; *gill trama* of narrow loosely interwoven hyaline hyphae as seen revived in KOH; *pileus trama* with a cuticle of vesiculose-pedicellate to sessile cells 15–30 μ in diam. and with smooth thin hyaline to slightly brownish walls as revived in KOH, flesh proper of loosely interwoven hyaline filamentous hyphae (in KOH); *universal veil* remnants filamentous in upper portion, next to the cap composed of chains of vesiculose cells, cells of the filaments 30–60 x (9) 10–18 μ, subcylindric to enlarged in mid-portion or irregular (enlarged only on one side), the walls (when revived in KOH) tawny cinnamon, slightly thickened, smooth or with only light incrustations of pigment, the vesiculose cells next to the cuticle paler to hyaline and also smooth, 15–36 μ in diam., both types somewhat separable and single cells or short segments of hyphae not uncommon in slightly crushed mounts.

Habit, habitat and distribution: Single to somewhat gregarious around stumps of frondose trees, Tennessee and Michigan (Hesler 14232; Smith 20438).

Discussion: This species is distinguished by the manner in which the gills are attached, the basal annulus and the conspicuous veil remnants. It might in a way be regarded as an extreme velose type of the *C. radians* series. We have

collected material of a number of intermediate species with similar organization of the veil, but in which it is more fibrillose-granular. In these the veil is more evanescent and no true warts are left on the expanding caps. The spores of all these are more or less cocoa-brown when first revived in KOH (if taken from dried specimens). Even spores taken from a deposit resemble those of species of *Psathyrella* more closely in coloration than those of typical Coprini. Lange's illustration of the unexpanded cap is paler than in our material at the same stage, but the mature specimen illustrated could have been taken from mature caps in the American collections. One can find a number of concepts of this species in the literature, some of which are quite out of line with the Friesian descriptions. Even when limited to the *C. radians* series there are still a number of species which might legitimately be placed under this name. Consequently it appears best to accept a clear concept such as Lange's in order to fix the name. Metrod has described this and two closely related species and also accepts Lange's concept for *C. domesticus*. The fungus described by Pennington as *C. domesticus* (Kauffman, Agar. Mich. p. 218) does not belong in this series of Coprini.

Coprinus elongatipes sp. nov. Fig. 1; C, D, E.

Pileus 2–5 cm. latus, conicus vel convexus, udus, glaber, hygrophanus, cinnamomeo-brunneus dein fulvus vel avellaneus, cum sicco atomatus, non plicatus; lamellae ferrugineo-brunneae, perangustae, confertae, adnatae, margine albo-fimbriatae; stipes 6–10 cm. longus 2–3 mm. crassus, fragilis, aequalis, sursum pruinosus, deorsum glaber, cavus; ozonium fulvum; sporae 10–12.5 x 6.5–8 μ, ellipsoideae vel subovoideae.

Pileus 2–5 cm. broad, conic to convex or with a conic umbo, not expanding, surface moist, glabrous or under a lens with appressed dark colored short hairs (the setae), hygrophanous, dark watery brown when wet, fading to grayish brown or tawny, atomate when faded, margin even; *flesh* thin, fragile, pale pinkish brown, odor and taste not distinctive; *lamellae* adnate, deep reddish brown, linear, rounded in front, close, edge whitish-fimbriate; *stipe* 6–10 cm. long, 2–3 mm. thick, very fragile and brittle, equal, apex pruinose, glabrous elsewhere, hollow, flexuous at base and with a surrounding dense mat of rusty brown mycelium and rhizomorphs (the ozonium).

Spores 10–12.5 x 6.5–8 μ, ellipsoid to subovoid, smooth, black in KOH, apical pore obscure under ordinary magnifications; *basidia* four-spored, 18–22 x 10–11 μ, hyaline in KOH, pale brownish in sections, clavate; *paraphyses* coprinoid; pleurocystidia none; *cheilocystidia* abundant, 32–44 x 10–18 μ, fusoid-ventricose to subellipsoid, apices often broadly rounded, thin-walled, hyaline in KOH; *gill trama* of large more or less parallel cells which are dark sordid cinnamon in KOH, subhymenium darker, *pileus trama* of enlarged dark-yellowish-brown hyphae; cuticle of inflated pale brown cells readily collapsing and difficult to demonstrate in sections revived in KOH, numerous tawny-brown setae 100–180 x 7–9 μ with thick flexuous walls present, their apices subacute and apical portion often yellow instead of tawny.

Habit, habitat and distribution: Among grass and weeds on soil in open deciduous woods, Estes Park, Rocky Mountain National Park, 8500 ft. elev., July 10, 1940, L. R. Hesler 12689-type.

Discussion: The pileus in this species soon deliquesces, but in spite of this

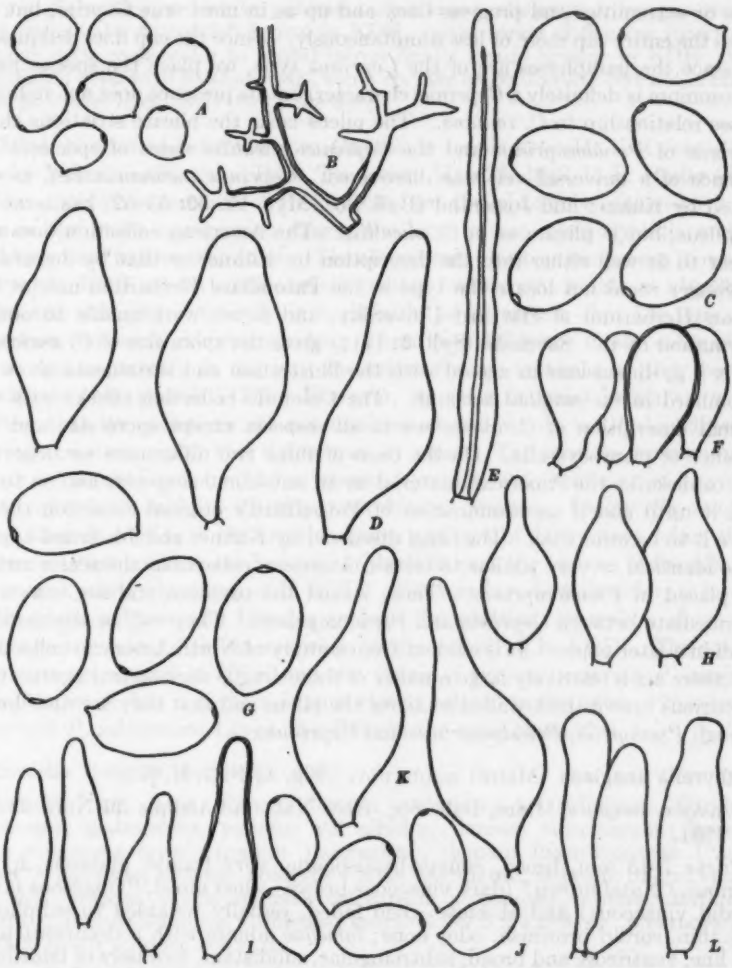

Fig. 1. *Coprinus Burkii: A*, spores; *B*, fragment of hypha from universal veil. *Coprinus elongatipes: C*, spores; *D*, cheilocystidia; *E*, seta from pileus. *Psathyrella anaglaea: F*, cheilocystidia; *G*, spores; *K*, pleurocystidia; *H*, cheilocystidia. *P. lauricola: I*, cheilocystidia; *J*, spores; *L*, pleurocystidia near gill edge.

The drawings were made with the aid of a camera-lucida and are reproduced at a magnification of 750 × for the cystidia and 1650 × for the spores.

character the fungus may actually be closer to *Psathyrella subatrata* and certain species in *Pseudocoprinus* than to any other fungi. The dissolving process in this species, to judge from the material examined, does not start at the gill

edges or extremities and progress back and up as in most true Coprini, but involves the entire cap more or less simultaneously. Since the cap does deliquesce, and since the paraphyses are of the *Coprinus* type, we place the species here. The ozonium is definitely a *Coprinus* character, but its presence does not indicate a close relationship to *C. radians*. The pileus lacks the plicate striations characteristic of *Pseudocoprinus* and the *Coprinus plicatilis* series of species. No evidence of a universal veil was discovered. *Coprinus auricomus* Pat. as described by Kühner and Josserand (Bull. Soc. Myc. Fr. **50:** 53–62) has setae on the pileus, but is plicate as in *C. plicatilis*. The American collection does not appear to fit well either into the description by Kühner or that by Josserand. Dr. Singer could not locate the type in the Patouillard Herbarium now at the Farlow Herbarium of Harvard University, and so we were unable to obtain information on it. Saccardo (Syll. **5:** 1114) gives the spore size of *C. auricomis* as 7 x 3 μ, dimensions in accord with the illustration and statements given by Patouillard in the original account. The Colorado collection checks with the original description of *C. auricomus* in all respects except spore size and the presence of pleurocystidia. On the basis of these two differences we believe it best to describe the American material as an autonomous species and so to regard it until and if an examination of Patouillard's original collection should prove it to be otherwise. The fungi discussed by Kühner and Josserand appear to be identical or very similar to certain American collections the senior author has placed in *Pseudocoprinus*. These lacked the ozonium and are somewhat intermediate between *Coprinus* and *Pseudocoprinus*. They will be discussed in detail in a later paper. It is evident from a study of North American collections that there are a relatively large number of these fragile dark-spored agarics with the curious brown thick-walled setae on the pileus and that they are distributed through *Psathyrella*, *Pseudocoprinus* and *Coprinus*.

Psathyrella anaglaea (Maire) comb. nov. Fig. 1; F, G, H, K.

Psathyra anaglaea Maire, Bull. Soc. Hist. Nat. de l'Afrique du Nord **22**: 18. 1931.

Pileus 7–15 mm. broad, convex-hemispheric, very fragile, glabrous, hygrophanous, "Natal brown" (dark vinaceous brown) when moist, "vinaceous fawn" (sordid vinaceous) and atomate when faded, radially wrinkled to subplicate; *flesh* thin, sordid brownish, odor none; *lamellae* adnate with a decurrent tooth and line, ventricose and broad, subtriangular, subdistant, two tiers of lamellulae, "Benzo brown" (purplish brown) or when dried blackish brown, the edges "vinaceous fawn" at maturity; *stipe* 2–4 cm. long, 1–1.5 mm. thick, equal, hollow, fragile, dingy whitish when fresh, pale dull avellaneous when dried, easily splitting, glabrous except for the pruinose apex.

Spores 12–14.7 x 7–8 μ, smooth, ellipsoid to subovoid, black or blackish revived in KOH, apical pore present but inconspicous; *basidia* four-spored, hyaline in KOH, 23–28 x 10–12 μ, clavate; *pleurocystidia* scattered to rare, 36–63 x 12–16 μ, broadly ventricose above a narrow pedicel and apex acute to subacute, neck elongated, narrow, and distinctly narrowed above the ventricose portion, hyaline in KOH, smooth, thin-walled; *cheilocystidia* abundant, of two types, fusoid-ventricose and hyaline, or clavate and yellowish as revived in KOH, the former 30–36 x 9–12 μ and neck not elongated, the latter clavate to ellipsoid with

very slightly thickened walls; *gill trama* of enlarged cells more or less parallel and pale cocoa-color to reddish brown in KOH; *pileus trama* of floccose interwoven hyphae, pale cocoa-color to sordid tan or finally nearly hyaline in KOH; *cuticle* of inflated cells with hyaline walls, some clavate or pedicellate but not arranged in a palisade, irregularly two cells deep.

Habit, habitat and distribution: On soil in woods near Mt. LeConte, Great Smoky Mountains National Park, Tennessee, May 24, 1942, L. R. Hesler 14213.

The distinctive features of this species are the obscurely vinaceous brown pilei in the moist unexpanded stages, the large spores, pleurocystidia and the slightly sordid to brownish stipe. The almost coal black spores as seen in mounts revived in KOH are an additional distinctive feature which aids in identifying herbarium material. Actually it is difficult to be certain that the American collection represents Maire's species. There is a difference in the color of the pileus and apparently in the way the colors change in age, i. e. they become pinkish in collection H.14213. However, so little material is known of the species, that its variations are not established and we do not feel justified in placing emphasis upon the differences in color. The stature, commonplace aspect as pointed out by Maire, spores, cystidia, and tendency of the stipe to be colored all indicate identity with Maire's species. *Psathyrella anaglaea* differs from *P. trepida* in the broader spores and lack of dark russet colors of the buttons. *Psathyrella tenera* lacks pleurocystidia and the tramae of its gills and pileus are hyaline when revived in KOH. *Psathyrella rudericola* differs in having coprinoid paraphyses and broader spores. In addition, there is a sharp difference in the color of the spores when they are revived in KOH. The colored gill trama as revived in KOH and the colors of the cap separate *P. anaglaea* from *P. atomata*, but it perhaps is most closely related to the latter. *Psathyrella prona* and *P. subatomata* Lange also differ in the same characters.

Psathyrella insignis Smith sp. nov.

Pileus 3–7 cm. latus, obtusus demum umbonatus, vel subplanus, fibrilloso-squamosus, glabrescens, pallidus vel albidus, demum subvinaceus; lamellae "pale vinaceous fawn" (pallide incarnatae), demum fusco-vinaceae ("army brown"), guttatae, adnatae, confertae, latae, serrulatae; stipes 6–10 cm. longus, 8–12 mm. crassus, cavus, aequalis vel sursum attenuatus, albidus, fibrillosus, sursum annulatus; annulus fibrillosus; sporae 6.2–7.5 x 3.2–3.8 μ; pleurocystidia 34–42 x 10–15 μ, apice convexa.

Pileus 3–7 cm. broad, obtuse becoming plane or with a low obtuse umbo and a spreading margin, surface at first covered with the remains of a coarse white fibrillose universal veil, fibrils either remaining appressed and giving the surface a white-silky appearance or becoming aggregated into fascicles which remain more or less appressed and become slightly sordid in age, margin appendiculate with patches of fibrils, finally becoming glabrous over all, surface beneath the fibrils white to whitish when fresh and moist but becoming "light vinaceous fawn" to "fawn color" as the spores mature, often with "pinkish vinaceous" blotches or tinged that color along the margin, at times the disc "pale pinkish buff", hygrophanous but scarcely changing color when fading, margin opaque at all stages; *flesh* moderately thick, rather brittle, watery, "pale vinaceous fawn" becoming "vinaceous buff", pallid when faded, odor and taste not distinctive;

lamellae "pale vinaceous fawn" becoming "army brown" (reddish as in *P. sarcocephala*), beaded with drops of moisture at first and in age spotted as a result, depressed-adnate, close to crowded, moderately broad, 5–6 mm., edges finely serrate; *stipe* 6–10 cm. long, 8–12 mm. thick, hollow, equal or narrowed slightly below, white throughout and unchanging, mycelium at base and that surrounding the base of stipe yellowish in some collections or in areas in the same collection, surface coarsely appressed white-fibrillose from veil remnants, remains of veil terminating in an apical to median zone, white silky-floccose above.

Spores 6.5–7.5 x 3.2–3.8 μ, sordid cocoa-brown in deposits, oblong in face view, slightly bean-shaped in side view, cocoa-color as revived in KOH; *basidia* 18–20 x 6–7 μ, hyaline, four-spored; *pleurocystidia* scattered, hyaline in KOH, apices rounded to obtuse, 34–42 x 10–15 μ; *cheilocystidia* similar to pleurocystidia or clavate to saccate, the former 28–35 x 10–14 μ, the latter 17–26 x 8–14 μ, hyaline or yellowish when revived in KOH, cuticle of inflated cells and 2–3 cells deep.

Habit, habitat and distribution: Cespitose around stumps of locust and beech, Ann Arbor, Mich., Sept. 30, 1945, Smith 20789-type.

Discussion: This species is intermediate between the sections Drosophilae and Hypholomatae of the authors' classification of *Psathyrella*. The relationships of *P. insignis* appear to be with *P. lacrymabunda* and *P. aggregata*, but it is fundamentally distinct by virtue of the superficial white universal veil. *Psathyrella lacrymabunda* differs further in having pleurocystidia which color when mounted in KOH. *Psathyrella aggregata* differs in the color of the gills as well as in the color of the veil. Its gills are grayish when young instead of pinkish. Although spore prints of the two species have not been compared, I suspect the difference there is rather striking. *Hypholoma coloneum* sensu Lange is close and the variety which he discussed is said to have whitish and then fuscescent fibrils on the cap. However its spores are larger. Lange though it not improbable that this variety actually represented an autonomous species, but apparently felt that his information was not complete enough to justify treating it as such. One very luxuriant fruiting of *P. insignis* was discovered and material of all ages observed.

Psathyrella lauricola sp. nov. Fig. 1; I, J, L. 2; A.

Pileus 1–2.5 cm. latus, obtusus demum convexus, glaber, hygrophanus, subcinnamomeus ("snuff brown") dein pallide ochraceus, demum lividus, atomatus; lamellae adnatae, subdistantes, latae, atrobrunneae, margine albo-fimbriatae; stipes 3–5 cm. longus, 1.5–2 mm. crassus, aequalis, albidus, subfibrillosus; sporae 8–10 x 4–5 μ, ellipsoideae vel subovoideae, subatratae; pleurocystidia (36) 44–62 (70) x 8–12 μ, subcylindrica, apice rotunda.

Pileus 1–2.5 cm. broad, obtuse to convex, the margin appressed at first, surface glabrous, not conspicuously striate, when moist "snuff brown" or more yellowish on the disc (sordid cinnamon to sordid ochraceous), the disc remaining tinged with ochraceous but the remainder soon grayish and finally blackish umber, hygrophanous, fading to sordid cinereous on the margin and buff on the disc, conspicuously atomate when fading; *flesh* very thin and fragile, odor and taste not distinctive; *lamellae* adnate, subdistant, broad, blackish brown, edges whitish; *stipe* 3–5 cm. long, 1.5–2 mm. thick, equal, white, sparsely fibrillose, tubular, rather firm.

Spores 8–10 x 4–5 μ, smooth, ellipsoid to subovoid, blackish brown in water

mounts of fresh material, dark blackish to bister when revived in KOH, apical pore distinct, hyaline and lens-shaped; *basidia* 14–17 x 7–8 μ, with a short broad pedicel, four-spored, hyaline in KOH; *pleurocystidia* thin-walled, subcylindric, with broadly rounded apices, a few somewhat ventricose in midportion, (36) 44–62 (70) μ x 8–12 μ; *cheilocystidia* similar to pleurocystidia but shorter and more typically fusoid-ventricose and with merely obtuse apices; *gill trama* regular, of large cells rather irregularly arranged, pale brown to rusty brown in KOH; *pileus trama* floccose and interwoven, pale rusty brown in KOH; cuticle of vesiculose hyaline cells one cell deep or irregularly two cells deep, not organized into a palisade.

Habit, habitat and distribution: Cespitose on a laurel stub, Grassy Patch, Great Smoky Mountains National Park, Tenn., Sept. 1, 1938, L. R. Hesler and A. H. Smith 10793-type.

Discussion: There were no signs of a veil on buttons, but the scattered fibrils of the stipe in the more mature fruiting bodies may indicate that a rudimentary veil is at times present. According to the senior author's experience with other species, a veil would be expected here on at least some of the carpophores of a collection. This is one species of *Psathyrella* which has a spore deposit as black as that of most species of *Coprinus*, and under the microscope the spores are a bister rather than a choclate brown when revived in KOH. *Psathyrella lauricola* differs from *P. microsperma* in spore size as well as in the color of the spores and in the size of the apical pore. From an inspection of the fresh fruiting bodies one might think that the fungus was nothing more than a form of *Coprinus micaceus* but the carpophores do not deliquesce (they were collected in wet weather and were mature). The microscopic characters will distinguish it at once. The paraphyses of *P. lauricola* are not typically coprinoid and since the pileus is not plicate the species cannot be referred to *Pseudocoprinus* although it appears to be related to that group by the very delicate flesh and spore characters.

Psathyrella piceicola sp. nov. Fig. 2; B, C, E.

Pileus 2–3.5 cm. latus, conicus, demum late campanulatus, ad marginem rugulosus, floccoso-squamulosus, demum glaber, cum cicco melleus; lamellae adnatae, secedentes, latae, confertae, spadiceae, margine albo-fimbriatae; stipes 5–12 cm. longus, 4–6 mm. crassus, subaequalis, apice pruinosus, deorsum squamosus; sporae 12–15 (18) x 6–7.5 μ; basidia tetraspora; pleurocystidia 50–90 x 12–20 μ, ventricosa, obtusa vel subcapitata; cheilocystidia anguste ventricosa vel subcylindrica, 50–80 x 7–12 μ.

Pileus 2–3.5 cm. broad, conic, becoming broadly umbonate and campanulate to more or less expanded, surface with the marginal two-thirds radially rugulose and near the margin with concentric flattened scales from the remains of the heavy veil, glabrescent, dry (probably collected when faded), near cinnamon buff to honey color with the disc buckthorn brown, when dried the disc sordid tawny to reddish brown and the margin paler yellowish brown, the surface appearing as if varnished in some but no gelatinous layer present, margin appendiculate with the submembranous patches of veil tissue; *flesh* thick in the disc, abruptly thin outward, white, firm, odor strongly fungoid, taste mild and pleasant at first, finally bitterish; *lamellae* adnate, usually joined at the stipe, seceding, broad, close to crowded, warm sepia or slightly paler, edges whitish, ciliate;

stipe 5–12 cm. long, 4–6 mm. thick, apex mealy, glabrous and shining to the midportion, lower down conspicuously lacerate-squamulose to scaly, equal or tapering upward, stuffed becoming hollow, rooting; veil heavy and fibrous.

Spores dark purple brown in mass, 12–15 (18) x 6–7.5 μ, narrowly ovoid to ellipsoid in front view, slightly inequilateral in side view, smooth, apiculus very distinct, apical pore very inconspicuous, when revived in KOH sordid cinnamon brown to pale bister clouded with purple-brown in some; *pleurocystidia* abundant, 50–90 x 12–20 μ, ventricose and with greatly elongated necks and broadly rounded apices, subcapitate in some, thin-walled, smooth, hyaline in KOH, a few with one or more knoblike projections or contorted prolongations; *cheilocystidia* narrowly ventricose to subcylindric or with flexuous walls at least in age, 50–80 x 7–12 μ, thin-walled, apices obtuse and often with adhering mucilage, hyaline to pale smoky yellowish brown in KOH, very abundant, *gill trama* of parallel hyphae, hyaline or faintly sordid yellowish in KOH; *pileus trama* of floccose interwoven hyphae, pale sordid yellowish in KOH; *cuticle* of a layer of vesiculose cells irregularly two to three cells deep, their walls pale cinnamon brown in KOH.

Habit, habitat and distribution: Subcespitose (2–3 in a cluster) on decayed spruce logs, Indian Gap, Tennessee, June 22, 1941, coll. S. L. Meyer (Hesler 13783-type).

Discussion: This species possesses a number of very distinctive characters. In the first place not many species in this genus inhabit the wood of conifers, and few of the lignicolous species have such large spores. These two characters in conjunction with the well developed veil make an unusual combination. Similar pleurocystidia are found in *P. Barlae* but in that fungus their apices are not as broadly rounded, and the colors of the fruiting bodies are very different. The color of the spores when revived in KOH approaches that which is characteristic of the genus *Psilocybe*.

Psathyrella rudericola Smith sp. nov.

Pileus 1.5–3 cm. latus, conicus demum campanulatus, glaber, lubricus, vinaceo-umbrinus, pallescens; lamellae pallide vinaceae demum fuscae, confertae, angustae, adnatae; stipes 3–5 cm. longus, 1.5–2.5 (3) mm. crassus, cavus, fragilis, albidus, sursum pruinosus, deorsum subfibrillosus; sporae 11–13 x 5.5–6.5 μ; haud pleurocystidia; cheilocystidia dispersa vel rara, 36–48 x 10–14 μ.

Pileus 1.5–3 cm. broad, obtusely conic with an appressed margin at first, becoming conic-campanulate, rarely expanding further, a rudimentary veil sometimes present, surface glabrous, moist, lubricous, evenly "natal brown" when young (with a distinct vinaceous tinge), fading to sordid gray or on the disc watery pale sordid alutaceous, surface closely wrinkled-striate to near disc but not becoming plicate-striate as in *Pseudocoprinus*; *flesh* very delicate, thin, fragile, odor and taste none; *lamellae* "light vinaceous fawn" (pale vinaceous) young, becoming pallid and finally "hair brown" (dark drab), close, very narrow, ascending adnate, edges even; *stipe* 3–5 cm. long, 1.5–2.5 mm. thick at apex, hollow, fragile, white and unchanging, pruinose above, slightly fibrillose below, glabrescent.

Spores 11–13 x 5.5–6.5 μ, narrowly ellipsoid to subovoid, chocolate gray in KOH, smooth, apical pore very indistinct; *basidia* 20–24 x 10–12 μ dimorphic, four-spored; *paraphyses* coprinoid, 18–26 x 10–18 μ; *pleurocystidia* none; *cheilocystidia* rare to scattered, clavate to fusoid-ventricose with obtuse apices, 36–48 x 10–14 μ, *gill trama* of irregularly arranged inflated cells, hyaline when revived

in KOH and in water mounts of fresh material; *pileus trama* with a cuticle of inflated vesiculose cells, flesh proper of loosely arranged enlarged hyphal cells with hyaline metallic-appearing lactifers scattered through it, hyaline in water mounts of fresh material and when revived in KOH.

Habit, habitat and distribution: Gregarious to scattered on a compost pile composed of tropical plant remains, University Botanical Gardens, Ann Arbor, Mich., June 18, 1945, A. H. Smith 20445-type.

Discussion: This species is probably tropical or subtropical and was very likely introduced by being present on the plants sent to the Garden. It has a number of features characteristic of southern species of *Psathyrella*. The spores are relatively pale when revived in KOH, a character noted on a number of Murrill's subtropical species; pleurocystidia are lacking, a feature of many more subtropical than northern species; and the carpophores are of a very soft consistency. It can be distinguished at once in button stages by the dark vinaceous brown color of the cap and pale vinaceous tint of the gills. It approaches the genus *Pseudocoprinus* by having coprinoid paraphyses and dimorphic basidia, but lacks the plicate-striate condition of the cap. Even in the very old caps the wrinkled-striate condition did not change to plicate-striate. The veil is rudimentary. The species does appear to be closely related to *P. debilis* Pk. which also has coprinoid paraphyses and lacks pleurocystidia, but is at once distinguished by its spores and colors. *Psathyrella cubensis* Murrill has spores 9–12 x 7–8 μ which are blackish brown when revived in KOH. Its cap is described as pale reddish brown to rosy isabelline. *Psathyrella squamifera* Karst. lacks vinaceous tints in the cap and gills, and according to Lange, has rather sharply pointed cystidia. The vinaceous tints in *P. rudericola* are not those characteristic of faded carpophores in many species of *Psathyrella*, but instead are most typical on the expanding moist buttons. The species is very distinct from *P. bipellis* and its relatives because of the lack of pleurocystida and different pattern of color change.

Psathyrella subvolvata sp. nov. Fig. 2; D, E, G.

Pileus 2.5 cm. latus, obtusus, demum subumbonatus, siccus, dense fibrillosus, candidus, subglabrescens; lamellae confertae, latae, candidae demum purpureofuscae; stipes 2.5 cm. longus, 3 mm. crassus, aequalis, ad basim subbulbus, albidus, cavus, sursum pruinosus, deorsum fibrillosus, ad basim fibrilloso-volvatus; sporae 6.5–7.5 x 3–3.5 μ; pleurocystidia 28–36 x 10–12 (14) μ, obtusa.

Pileus 2.5 cm. broad, obtuse, becoming broadly subumbonate, surface appearing dry because of a dense covering of innate long white fibrils which become aggregated into fascicles around the disc, the margin incurved and striatulate at first beneath the fibrils, more or less glabrescent part way to disc in age, entirely white at first (beneath the fibrils) but becoming tinged umber as the spores mature; *flesh* fragile, white, hygrophanous, odor and taste not distinctive; *lamellae* close and broad ($\pm$ 5 mm.), shallowly adnexed, white, slowly becoming "benzo brown" (a dull purplish brown), edges slightly paler and nearly even; stipe 2.5 cm. long, 3 mm. thick, equal except for the subbulbous base, white, hollow, bulb surrounded by a white mass of fibrils which almost form a volva, densely fibrillose over lower half, pruinose above.

Spores 6–7.5 x 3–3.5 μ, smooth, oblong in face view, curved to somewhat bean-shaped in side view, pale chocolate brown in KOH, apical pore very inconspicuous; *basidia* four-spored, 16–19 x 6–6.5 μ, hyaline in KOH, slightly clavate,

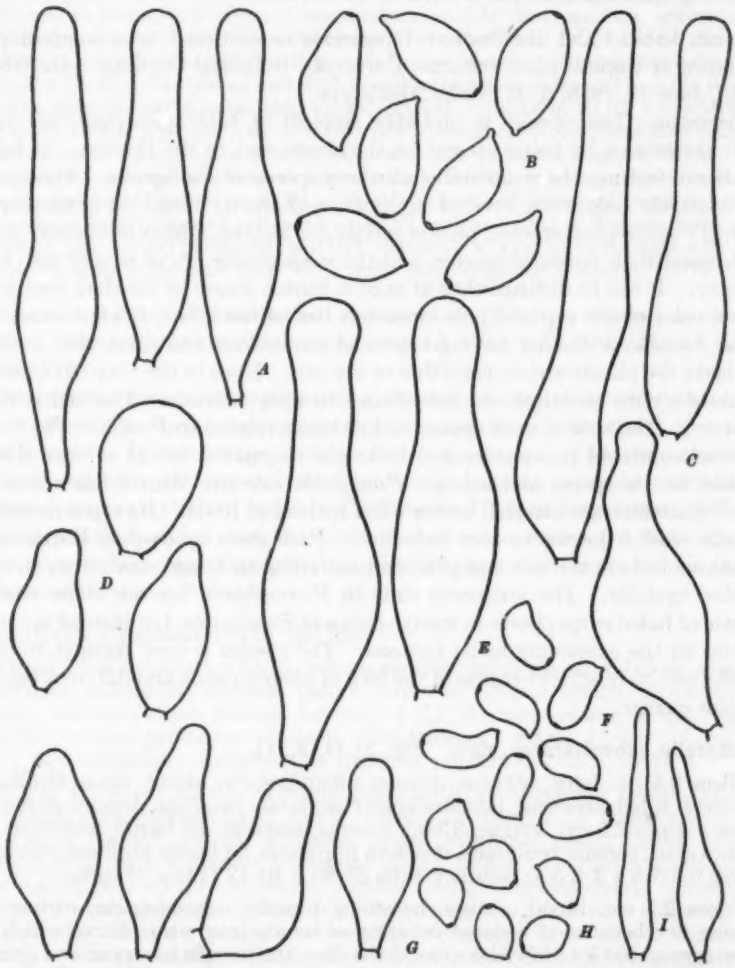

Fig. 2. *P. lauricola: A*, pleurocystidia. *P. piceicola: B*, spores; *C*, cheilocystidia; *E*, pleurocystidia. *P. subvolvata: D*, cheilocystidia. *F*, spores; *G*, pleurocystidia. *Psilocybe acadiensis: H*, spores. *P. angustispora: I*, cheilocystidia.

bases not conspicuously narrowed; *pleurocystidia* abundant, 28–36 (40) x 10–12 (14) μ, ventricose but with only a short neck and obtuse to broadly rounded apex, hyaline in KOH; *cheilocystidia* similar to pleurocystidia or merely clavate, both types hyaline in KOH and thin-walled; *gill trama* of narrow parallel hy-

phae, hyaline in KOH; pileus trama of compactly interwoven hyphae, hyaline in KOH; *cuticle* of hyaline vesiculose cells in a layer irregularly two to three cells deep or if cells very large (60 x 40 μ or more) only one cell deep, hyaline, filamentose hyphae 6–10 μ in diameter originating in the cuticle and remaining appressed over the surface.

Habit, habitat and distribution: Single on soil beside a trail, Indian Camp Creek, Great Smoky Mountains National Park, Tennessee, Aug. 30, 1938, L. R. Hesler and A. H. Smith 10660-type.

Discussion: Although known only from a single specimen this species is so distinctive that it should be placed on record. It appears to be most closely related to *P. epimyces*, but differs in its smaller spores (7–9 x 4–5 μ in *P. epimyces*), habitat (which in this case appears to be a very important difference), and much more slender stipe. *Psathyrella epimyces* may appear to be volvate at times because of the manner in which the veil breaks. The characters which place *P. subvolvata* close to *P. epimyces* are the obtuse cystidia, the well developed white veil which is more or less innate, and the manner in which the veil breaks. When more material of *P. subvolvata* is obtained it will very likely show some variation in the manner in which the veil remnants are distributed around the base of the stipe or over its lower portion so we do not believe it justifiable to insist that the species is typically volvate. *Psathyrella subvolvata* appears close to the *P. lacrymabunda* group by virtue of its spores and pleurocystidia. It resembles *P. insignis* in some respects, but the veil is more copious and loosely organized, and the manner in which the remnants are distributed around the bulbous base of the stipe suggest a development comparable to that of species of Bulbopodium in *Cortinarius*, a feature which at once distinguishes it from any other *Psathyrella* known to us. This type of development, however, is not uncommon among the small sylvan species of *Coprinus* with somewhat granulose universal veils.

Pseudocoprinus Besseyi Smith sp. nov.

Pileus 1–2.5 cm. altus, 15–20 mm. crassus, conicus, subviscidus, glaber, demum convexus et udus, levis demum plicato-striatus, castaneus demum incarnato-cinnamomeus; lamellae confertae demum subdistantes, adnatae, angustae; stipes (3) 5–8 (9) cm. longus, 3–4.5 mm. crassus, aequalis, subalbidus, glaber; sporae 12–15 (16) x 7–7.5 x 8–8.5 μ; pleurocystidia 100–160 x 20–30 μ, subventricosa, obtusa; cheilocystidia vesiculosa vel ventricosa, 16–25 x 10–18 μ vel 28–42 x 12–16 μ.

Pileus cylindric to subcylindric, the margin straight, 1–2.5 cm. high and up to 15 mm. across the base, becoming conic but finally more or less convex (if conditions of development are perfect), often splitting radially before expansion is complete, glabrous, thinly glutinous to viscid or very lubricous when moist, evenly "chestnut" (dark bay) over all, hygrophanous, fading to near "Verona brown" on margin and "light pinkish cinnamon" around the watery disc, surface smooth at first but becoming wrinkled-striate to closely folded-striate over the marginal area, the striae extending irregular distances toward the apex, becoming plicate-striate just prior to splitting, disc smooth at first but at times becoming reticulate; *flesh* thin and very fragile, odor and taste not distinctive; *lamellae* very crowded but more distant as cap expands, ascending adnate, narrow, even,

"light pinkish cinnamon" becoming dark dull cocoa-color and finally chocolate brown, edges white fimbriate in some; *stipe* 3–6 (8) cm. long, 3-4.5 mm. thick, equal or nearly so, dull white or hardly tinged brownish, not discoloring, perfectly glabrous, no veil present.

Spores 12–15 (16) x 7–7.5 x 8–8.5 μ, very slightly flattened, dark rusty brown in H_2O when fresh, fuscous when revived in KOH, elliptic in side view or curved in slightly on inner side, ovate to subelliptic in face view, pore apical; *basidia* dimorphic, 24–32 x 10–13.5 μ, clavate, four-spored; *paraphyses* coprinoid, 30 x 20 μ, ellipsoid-pedicellate; *pleurocystidia* abundant to scattered, 100–160 x 20–30 μ, with rounded apices and midportion more or less ventricose, thin-walled, hyaline and readily collapsing; *cheilocystidia* vesiculose, or some fusoid-ventricose, 16–25 x 10–18 μ or 28–42 x 12–16 μ, hyaline; *gill trama* hyaline in KOH and H_2O on fresh material, pale cinnamon brown when revived in KOH; *pileus trama* dark cinnamon brown when revived in KOH, cuticle of a palisade of pedicellate cells, the basal portions brown when revived in KOH, setae scattered over surface and with thickened brown walls, 20 μ or more long, 4–5 (7) μ in diameter, the walls often undulating.

Habit, habitat and distribution: Scattered to gregarious around and on plant debris, in compost heaps, buried wood, sticks and on lawns but then usually from buried debris. Collected by E. A. Bessey, East Lansing, Michigan, Sept. 27, 1945-type. It fruits both during the spring and fall and is known from a number of localities in southern Michigan.

Discussion: Because of the bright bay color, viscid pileus on fresh button stages, large flattened spores and *Coprinus*-like pleurocystidia this is a most distinctive species. Because of the setae on the pileus it appears to be closely related to *P. gracillima* but the two can be readily distinguished in the field by the different colors. It is one of the larger species of the genus, but often fails to expand fully. Among the species of *Coprinus*, *C. Hansenii* Lange appears to be very similar in both macroscopic and microscopic characters. Lange (Fl. Ag. Dan. **4:** 118, 1939) states "marcescent, but hardly diffluent", a situation which tends to emphasize the similarity between the two. However, Lange's species is not described as having setae on the cap and he does not indicate that the button stages are viscid or subviscid. There may also be a difference in the spores but from the information at hand this is not certain. The spores of *P. Besseyi* are slightly flattened whereas such a character for *C. Hansenii* is not indicated. The latter is described as having free gills whereas in the American fungus the lamellae are adnate. *Psathyrella hydrophora* sensu Bresadola (Icon. Myc. pl. 888) is very similar and may be identical with *P. Besseyi*, but there is some confusion in regard to the concept of *P. hydrophora*. Certainly the concepts of Ricken and Bresadola each apply to a different species. *Psathyrella Besseyi* so far as observed never has a revolute margin and the gills are distinctly brownish and then reddish, not gray becoming livid. Also, there is no veil. Consequently the species cannot be considered identical with *P. hydrophora* in the sense of the Friesian descriptions, and it is not that of Rea either. Rather than add another variant species concept to the fungi known under this binomial it seems best to name the American collections and point out that the material differs from all concepts of *P. hydrophora* by the setae on the pileus and the much larger pleurocystidia.

Pseudocoprinus lacteus Smith sp. nov.

Pileus 10–15 mm. altus, 8–10 mm. latus, conicus, glaber, plicatostriatus, ad discum levis, lacteus vel "pinkish buff" (pallide argillaceus), demum lividus; lamellae adnatae, confertae, angustae, lacteae demum fuscae; stipes 3–5 cm. longus, 1 mm. crassus, aequalis, albidus, glaber, fragilissimus; sporae 8.4–10.5 x 5–6.3 x 7–8.4 μ; cheilocystidia distinctissima, 22–36 x (8) 10–16 μ.

Pileus 10–15 mm. high, 8–10 mm. across the base, obtusely conic when young and remaining conic till old age when stipe collapses, surface glabrous, soon plicate-striate to the smooth not sharply delimited disc, glabrous at all stages, color "tilleul buff" but disc gradually becoming "pale pinkish buff" and striate area pallid to livid (but pallid again after spores are discharged); *flesh* very delicate and membranous, no odor; *lamellae* adnate to apex of stipe or nearly free, close, narrow, equal or only a few lamellulae present, whitish, evenly dusted with black spores, merely pallid in age after spores have been discharged; *stipe* 3–5 cm. long, 1 mm. thick, equal, white, glabrous or only slightly frosted, very fragile.

Spores black in deposit, 8.4–10.5 x 5–6.3 x 7–8.4 μ, flattened, subtriangular and slightly apiculate at flattened base in face view, subellipsoid and with a slightly eccentric pore in side view, some merely obscurely angular-ovate in face view, blackish in KOH; *basidia* two- and four-spored, dimorphic; *paraphyses* coprinoid; *pleurocystidia* rare to absent or bunched near gill edges toward margin of cap, 28–36 x 10–16 μ, ventricose with rounded apices, content hyaline and homogeneous; *cheilocystidia* clavate to pedicellate-vesiculose and when revived in KOH with a highly refractive granular amorphous content, 22–36 x (8) 10–16 μ, content subhyaline to yellowish in KOH; gill trama narrow and hyaline in KOH; *pileus trama* with a cuticle formed by a hymeniform layer of clavate pedicellate to subcylindric cells 30–44 (60) x 9–14 μ, content as in the cheilocystidia, flesh proper hyaline in KOH.

Habit, habitat and distribution: Gregarious to scattered on bare soil in an oak woods, Ann Arbor, Mich. Sept. 12, 1945, A. H. Smith 20520-type.

Discussion: In stature and coloration this species is similar to *P. disseminatus*, but is at once recognized by its habitat and lack of hairs on the stipe. Under the microscope the two have only the generic characters in common. The flattened spores with the eccentric pore are distinctive enough even if one disregards the contents of the cheilocystidia and cuticular cells of the pileus. Nothing unusual was noted in regard to the contents of these cells when the fresh material was studied, but when revived in KOH they are very distinctive and somewhat similar to that which characterizes the cystidia of *Naematoloma*. The most unusual feature, of course, is that the cells forming the cuticle of the pileus should show similar contents. As far as the author of this species is aware, this is the only one in which this situation is encountered. The spores resemble those of *Coprinus plicatilis* in shape, color and pore characters, but the fungus cannot under any circumstances be referred to *Coprinus*. In moist weather there were no signs of deliquescing even on specimens so old the spores had all been shed and the stipes had collapsed. In *Coprinus*, however, it would appear to be close to *C. hiascens* sensu Lange, which deliquesces tardily. This *Coprinus*, however, differs in having a brownish pileus and differently shaped spores. *Coprinus hemerobius* of some authors is described as having gills which become dark with the spores and then become pallid when the spores have been

discharged, a situation which indicates that they were dealing with a *Pseudocoprinus* instead. However, both Ricken and Bresadola describe the spores of *C. hemerobius* as much larger than in *P. lacteus*, and other differences are also evident when descriptions of the two are compared. *Psathyrella crenata* sensu Konrad & Maublanc appears to be closely related but differs in having larger spores with a truly apical pore. All of these apparently also differ in the type of cheilocystidia and cuticular cells of the pileus.

Psilocybe acadiensis Smith sp. nov. Fig. 2; H. 3, A, D.

Pileus 1–2.5 cm. latus, obtuse conicus demum campanulatus vel umbonatus, albo-floccosus, glabrescens, viscidus, hygrophanus, subferrugineus dein argillaceus; lamellae angustae, confertae, late adnatae, pallidae demum fusco-purpureae, albo-fimbriatae; stipes 2–4 cm. longus, 2–2.5 mm. crassus, deorsum incrassatus, floccoso-fibrillosus, sursum sericeus; sporae 5–6 x 4–4.5 μ; cheilocystidia 28–40 x 5–6 μ, demum 50–70 x 3–5 μ.

Pileus 1–2.5 cm. broad, obtusely conic becoming obtusely campanulate to plane or expanded-umbonate, the margin incurved at first, surface with scattered white flecks of fibrils left from the universal veil or with a zone of flecks near the margin, glabrescent, viscid, hygrophanous, dark rusty brown when fresh ("Mars brown" to "Verona brown"), fading to ochraceous or clay color ("clay color"), fading on umbo first, margin striate when moist; *flesh* thin and fragile, odor and taste not distinctive; *lamellae* rather narrow, close to crowded, broadly adnate, whitish when young, becoming purplish brown, dull dark cinnamon brown when dried, edges white-fimbriate; *stipe* 2–4 cm. long, 2–2.5 mm. thick, equal above an enlarged base, tubular, flesh within dark brown like the cap, surface more or less covered by the copious remnants of the white veil causing it to appear white or whitish, with a median to superior evanescent fibrillose annulus but surface silky fibrillose with white fibrils above it, the somewhat enlarged base surrounded by an extensive mat of appressed white mycelium.

Spores 5–6.2 x 4–4.5 μ, smooth, in side view subellipsoid to slightly inequilateral, pore apical and small but distinct and apex appearing slightly truncate, in face view broadly ovate to subglobate with the sides slightly angled (some appearing almost triangular), dull yellowish brown when revived in KOH, purplish brown when fresh; *basidia* four-spored, hyaline in KOH (12) 14–18 x 4–6.5 μ; *pleurocystidia* none; *cheilocystidia* very abundant and conspicuous, when young narrowly ventricose to subcylindric, 28–40 x 5–6 μ, the apex often capped with mucilage, in age becoming filamentous and 50–70 x 3–6 μ, flexuous or straight and with a clamp connection at the cross wall at the base, content hyaline and homogeneous in KOH; *gill trama* parallel to subparallel, pale cinnamon brown in KOH but darker along the subhymenium; *pileus trama* with a well differentiated gelatinous pellicle of hyaline hyphae 1.5–3 μ in diameter and bearing clamp connections; the flesh proper compactly interwoven and pale cinnamon brown in KOH, the pigment incrusted on the hyphae.

Habit, habitat and distribution: Scattered on decaying stems of *Epilobium*, Upper Brookside, Colchester County, Nova Scotia, July 13, 1931 (Wehmeyer no. 618-type).

Discussion: This species is very easily recognized by its filamentous cheilocystidia, viscid pileus, copious veil, and habitat. The spores and gill attachment are typical of the genus *Deconica* as recognized by some authors, but the cheilo-

cystidia are unique. They are typical of *Psilocybe* insofar as they at first have the characteristic drop of mucilage adhering on or near the apex, but in old, elongated cystidia this usually cannot be demonstrated.

Psilocybe angustispora Smith sp. nov. Fig. 2; I. 3; B, C.

Pileus 2–6 mm. latus, 3–5 mm. altus, acute conicus demum conico-campanulatus, viscidus, glaber, obscure vinaceo-brunneus, pallescens; lamellae distantes vel subdistantes, triangulares, latae, fusco-purpureae; stipes 10–20 mm. longus, 0.5 mm. crassus, aequalis, incarnato-alutaceus, fibrillosus vel deorsum floccosus; sporae 12–15 x 5–6.5 μ, anguste ellipsoideae; cheilocystidia 24–32 x 4–6 μ, subfusoidea.

Pileus 2–6 mm. broad, 3–5 mm. high, sharply conic to conic campanulate, surface glabrous and viscid, dark reddish brown to near "Verona brown" moist, hygrophanous and pale pinkish tan when faded, the margin at first decorated with minute white fibrillose flecks from the remains of the veil; *flesh* very thin, pliant, odor and taste not recorded; *lamellae* distant to subdistant, triangular and short decurrent, broad, dark purple brown with whitish fimbriate edges; *stipe* 10–20 mm. long, 0.5 mm. thick, equal, delicate, pallid pinkish tan and more or less covered at first with pallid fibrils from the remains of the thin veil, at times lower portion fibrillose scaly, base white mycelioid.

Spores 12–15 x 5–6.5 μ, smooth, narrowly ellipsoid, sordid yellowish brown in KOH, apical pore distinct; *basidia* four-spored, 22–30 x 7–8 μ, some projecting one-fourth their length when sporulating, hyaline in KOH when isolated but usually appearing pallid tan in sections; *pleurocystidia* none seen; *cheilocystidia* abundant, hyaline, aciculate or nearly so, 24–32 x 4–6 μ, apices pointed and often capped with mucilage (which soon dissolves in KOH); *gill trama* parallel or nearly so, the hyphae yellowish brown in KOH; *pileus trama* homogeneous beneath a thick hyaline gelatinous pellicle, the hyphae dark yellowish brown to cinnamon brown in KOH.

Habit, habitat and distribution: Single or two to three carpophores on a dung pellet. It occurs on the dung of various wild animals such as elk and marmot during the spring and fall in the Olympic Mountains of Washington. The first collection was made at Graves Creek Inn, May 23, 1939. The type (Smith 14866) was collected at Lake Mills, on the northern side of the Peninsula, July 9, 1939. Material collected during October, 1941, was lost in drying.

Discussion: This species is distinguished from other dung-inhabiting species of *Psilocybe* by its long narrow spores. The spores of *P. coprophila* are distinctly broader as well as being obscurely angular in face view. The minute size of the carpophores of *P. angustispora* does not appear to be caused by lack of food for they were consistently small in both collections though the size of the dung pellets varied greatly. However, it would be interesting to study this character further by means of cultures.

Psilocybe Cokeriana sp. nov. Fig. 3; E, F, G, H.

Pileus 0.5–1.5 (2) cm. latus, obtusus demum convexus vel planus, udus, hygrophanus, cinnamomeo-brunneus dein argillaceus, glaber, margine albo-squamulosus demum glaber; lamellae confertae vel subdistantes, angustae demum latae vel subtriangulares, adnatae vel subdecurrentes; stipes 2–3.5 cm. longus, 1–1.5 (2) mm. crassus, aequalis, fibrillosus, intus spadiceus; sporae

(4.6) 5.6–6.2 x 3–3.5 x 3.2–4 (4.4) μ, truncatae; pleurocystidia 26–32 x 8–12 μ vel 12–17 x 3–6 μ, distinctissima.

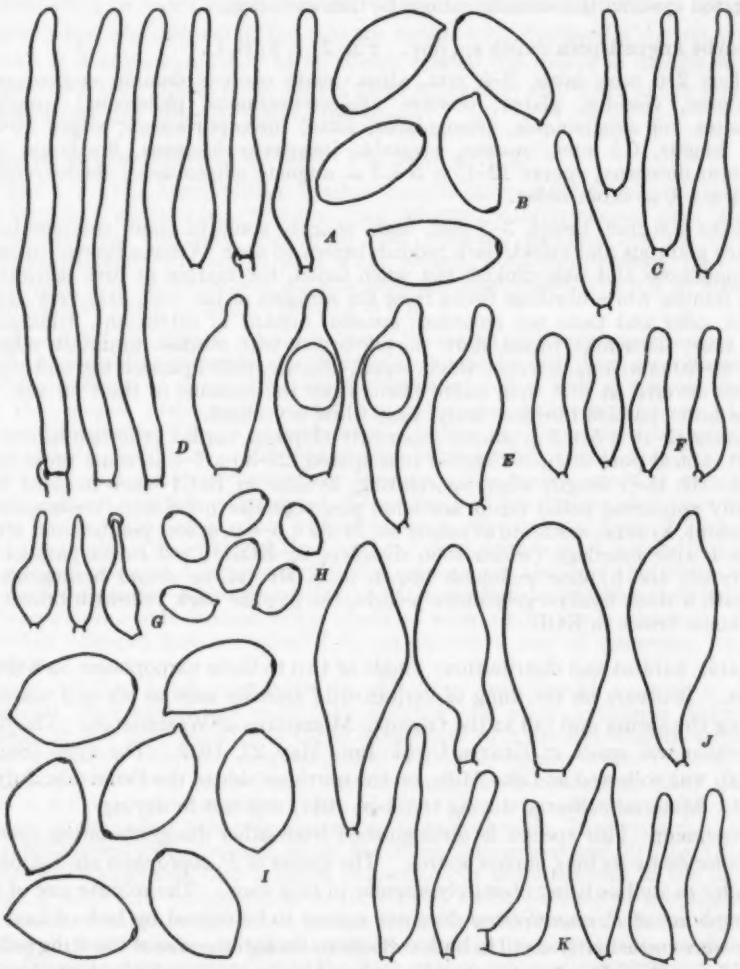

Fig. 3. *Psilocybe acadiensis: A*, cheilocystidia from young cap; *B*, cheilocystidia from old cap. *P. angustispora: B*, spores; *C*, *cheilocystidia*. *P. Cokeriana: E*, pleurocystidia with and without refractive content (type 1); *F*, pleurocystidia of type 2; *G*, cheilocystidia; *H*, spores. *P. subbrevipes: J*, pleurocystidia; *I*, spores; *K*, cheilocystidia.

Pileus 0.5–1.5 (2) cm. broad, obtuse becoming convex to plane, surface moist, hygrophanous, glabrous or with small white evanescent particles of veil tissue along the margin, nearly cinnamon brown moist, fading to pale cinnamon buff or "pinkish buff"; *flesh* soft, concolorous with surface, taste mild or somewhat

like that of a green gourd; *lamellae* thin, close to subdistant, narrow becoming broad and subtriangular, bluntly adnate or decurrent by lines down the stipe, "Mikado brown" (vinaceous cinnamon) when fresh, when dried pale sordid cinnamon or a duller vinaceous brown; stipe 2–3.5 cm. long, 1–1.5 (2) mm. thick, equal, bister when dried, flesh blackish when fresh, surface more or less covered by pale grayish to pinkish buff fibrils, base almost naked to somewhat strigose.

Spores (4.6) 5.6–6.2 x 3–3.2 x 3.2–4 (4.4) μ, slightly flattened, suboval and some obscurely angular in face view, subelliptic to slightly inequilateral in side view, pore apical causing apex to appear truncate; *basidia* hyaline in KOH, 10–13 x 4.5–6 μ, four-spored; *pleurocystidia* of two types, one ventricose to subcylindric and mucronate, 26–32 x 8–12 μ, content homogeneous and highly refractive or with a large central oil drop (not with an amorphous highly refractive body as in species of *Naematoloma*), the second type 12–17 x 3–6 μ, fusoid-ventricose with obtuse to broadly rounded apices, both types thin-walled and hyaline; *cheilocystidia* 12–15 x 3–7 μ, ventricose with an elongated neck and acute apex, hyaline, often with a drop of mucilage on the neck or over the apex as seen when revived in KOH; *gill trama* cinnamon brown, paler in central portion, darker near subhymenium, central strand interwoven, parallel next to subhymenium; *pileus trama* homogeneous beneath a very thin pellicle of narrow hyaline subgelatinous hyphae, tramal body pale cinnamon brown in KOH, darker toward the subhymenium, clamp connections present.

Habit, habitat and distribution: Solitary on a log in one collection from Alabama (Burke, AD) but cespitose on chipdirt in the collection from Knoxville, Tennessee (Hesler, June 22, 1934, 3952-type).

Discussion: The difference between the broad pleurocystidia of this species and those found in *Naematoloma* is best realized by a comparison of sections of each mounted in KOH and viewed under the microscope. However, since *P. Cokeriana* has the characters of a typical *Deconica*, i.e., small slightly compressed, obscurely angular spores and subdecurrent gills, it is not likely to be confused with the slender species of *Naematoloma* such as *N. squalidellum*. It is another of the species which make the establishment of clear-cut generic concepts in this group difficult even when one attempts to make arbitrary limits. The content of the large pleurocystidia when properly revived in KOH appears to be in the nature of an oil drop rather than the amorphous material found in the pleurocystidia of *Naematoloma*, but just how much difference there really is between the two compounds involved is problematic. Since the fungus is obviously *Deconica*-like in stature, it is placed in *Psilocybe*. It is named in honor of Dr. W. C. Coker in recognition of his work on and his life-long interest in the gill fungi.

Psilocybe subbrevipes sp. nov. Fig. 3; I, J, K.

Pileus 1–.5 cm. latus, convexus vel hemisphericus, glaber vel atropunctate squamulosus, lubricus vel subviscidus, hygrophanus, spadiceus demum fulvus; lamellae subdecurrentes, latae, triangulares, pallidae demum fusco-purpureae, margine albo-fimbriatae; stipes 2–2.5 cm. longus, 1–1.5 mm. crassus, aequalis, subspadiceus, fibrillosus; sporae 10–13.6 x 7–8.6 μ, ellipsoideae vel obscure angulares; pleurocystidia 30–42 x 10–13 μ, ventricosa, apice abtusa vel mucronata, hyalina.

Pileus 1–1.5 cm. broad, convex to hemispheric, not umbonate, surface lubricous to subviscid, substriate, glabrous or dotted with minute blackish squamules, dark watery brown when wet, tawny when faded, drying dark reddish brown; *flesh* concolorous with surface, thin except on the disc; *lamellae* broad (± 7 mm.), adnate-decurrent, extending about 5 mm. down the stipe as prominent ridges, triangular, pallid then dark brown, dusted by the spores, edges white fimbriate; *stipe* 2–2.5 cm. long, 1–1.5 mm. thick, hollow, equal, brown (concolorous with pileus when dried), fibrillose, base white mycelioid.

Spores dark purple brown in mass, 10–13.6 x 7–8.6 μ, ellipsoid to ovoid and obscurely angular, not appreciably flattened, dark sordid yellowish brown to almost bister in KOH, apical pore present but very small; *basidia* four-spored, 24–28 (30) x 9–10 μ, clavate to subcylindric, pale yellowish (as seen in sections) in KOH; *pleurocystidia* 30–42 x 10–13 μ, rare, hyaline, thin-walled, content homogeneous, ventricose above a more or less well developed pedicel, apex obtuse to obtusely mucronate, some clavate-mucronate but their content also homogeneous; *cheilocystidia* 22–28 x 5–7 μ, fusoid-ventricose, hyaline, thin-walled, abundant; *gill trama* interwoven, yellowish brown in KOH; *pileus trama* with a thin gelatinous pellicle of brownish to nearly hyaline narrow (2–3.5 μ) hyphae over the surface, hypoderm differentiated only by the dark brown color of its hyphae, the flesh beneath paler brownish and of compactly interwoven hyphae 8–14 μ in diameter.

Habit, habitat and distribution: Scattered on soil in woods of deciduous trees, La Follette, Tennessee, July 11, 1934, L. R. Hesler 10149-type.

Observations: This species, by virtue of its stature, would be placed in the *P. atrorufa* group were it not for its habitat on soil, its large spores and its pleurocystidia. The pleurocystidia resemble those of species of *Naematoloma* in all respects save that they do not have the characteristic highly refractive content when revived in KOH. The spores, which are obscurely angular in face view, are similar to those of the large-spored species of *Stropharia* and *Psilocybe* which occur on dung. Because of the combination of characters which it possesses it may be regarded as one of the fungi intermediate between *Stropharia, Naematoloma* and *Psilocybe* but properly placed in *Psilocybe* because of the manner in which the generic distinctions are drawn. It has the gills of a *Deconica* if that genus were to be recognized by the character upon which it was originally based. However, in view of the manner in which it appears advisable to distinguish *Stropharia, Naematoloma* and *Psilocybe*, the recognition of other genera such as *Deconica* would only make the classification more difficult to use and would not serve to express relationships more clearly.

Psilocybe Leechii Smith sp. nov. Fig. 4; A, B, C.

Pileus 2–4.5 (5) cm. latus, convexus demum hemisphericus vel subumbonatus, glaber vel margine subfibrillosus, fulvus, pallescens, lubricus demum siccus; lamellae latae, adnatae, confertae, pallidae demum "cinnamon drab" (subfuscae); stipes 3–7 cm. longus, 2.5–5.5 mm. crassus, aequalis, cavus, pallide alutaceus, pruinosus vel deorsum subfibrillosus; sporae 13–16 x 9–11 μ; pleurocystidia 36–52 x 9–12 μ, subcapitata.

Pileus 2–4 (5) cm. broad, convex with an inrolled margin becoming hemispheric to slightly umbonate, glabrous or with very slight remnants of a white rudimentary veil along the margin when young, ochraceous tawny over all and

gradually becoming pale tan, lubricous when fresh but soon dry; *flesh* thick, pallid, odor and taste not recorded; lamellae rounded adnate to adnexed, broad, close, two tiers of *lamellulae*, pallid becoming nearly "cinnamon drab"; *stipe* 3–7 cm. long, 2.5–5.5 mm. thick, equal or nearly so, hollow, pallid alutaceous but gradually darkening to grayish but when dried becoming alutaceous again, pruinose over all or with scattered fibrils over the lower portion from the veil.

Spores near "benzo brown" in deposits, ochraceous tawny when revived in KOH, 13–16 x 9–11 μ, smooth, thick-walled, hyaline pore very small and slightly eccentric as seen is a side view of the spore (spore not appearing truncate); *basidia* two-spored, hyaline in KOH, 34–40 x 9–10 μ; *pleurocystidia* 36–52 x 9–12 μ, rare to scattered, hyaline in KOH, thin-walled, ventricose with broadly rounded to capitate apices, some becoming subcylindric; *cheilocystidia* similar to pleurocystidia but smaller, some only 18–24 x 5–6 μ and fusoid-ventricose; *gill trama* hyaline in KOH, interwoven; *pileus trama* bright tawny brown in a region just below the cuticle (the hypoderm), the pigment incrusted on the hyphae, hyaline toward the subhymenium, cuticle of a compact palisade of narrowly clavate cells 30–40 x 4–7 μ, pale yellowish above, tawny toward the base, with thickened walls downward, thin-walled portion soon collapsing, clamp connections present on hyphae of the flesh.

Habit, habitat and distribution: Gregarious on lawns and grassy areas, Los Angeles, California (U.C.L.A. campus), Feb. 18, 1945, Rupert Leech no. 1-type. Several collections of this species were made during 1945.

Discussion: The truly purple-brown spores would place the fungus here in *Psilocybe* rather than in *Agrocybe* where one would expect to find it because of the nature of the cuticle of the pileus. The features which distinguish it as a species are the pleurocystidia, the very small subapical pore of the spores, the poorly developed veil, and the thick-walled pedicels of the cells which form the palisade over the pileus. Actually the cells of this palisade are quite peculiar and not typical of any species of *Agrocybe* known to me. In most species of *Agrocybe* the palisade cells are relatively short and inflated instead of narrowly clavate and with thick-walled pedicels. Since Singer places *Agrocybe* in the Bolbitiaceae, and since the relationships of this species do not appear to justify its being placed in that group even if there is some resemblance to *A. semiorbicularis* superficially, it is placed generically on the basis of its spore color in deposits even though this character has been observed to break down between certain groups of the Strophariaceae.

Psilocybe sphagnicola Smith sp. nov. **Fig. 4; D, E.**

Pileus 10–15 mm. latus, conico-campanulatus, glaber vel margine fibrillosus, subviscidus, hygrophanus, subferrugineus dein subochraceus; lamellae confertae vel subdistantes, latae, late adnatae vel subdecurrentes, avellaneae demum purpureo-fuscae, albo-crenulatae; stipes 7–9 cm. longus, 1–15 mm. crassus, aequalis, fibrillosus, sursum subpruinosus, deorsum demum subferrugineus; velum argillaceum; sporae 5.5–6.5 (7.5) x 4–4.5 (5.5) μ; cheilocystidia (26) 30–40 x 4–8 μ.

Pileus 10–15 mm. broad, conic-campanulate with an incurved margin at first, glabrous except for white patches of veil remnants adhering along the margin, slightly viscid when moist, hygrophanous, dark reddish brown (near "russet")

and fading to ochraceous buff, dull cinnamon buff when dried; *lamellae* moderately close to subdistant broad, broadly adnate to subdecurrent, pale grayish brown becoming dark purple-brown, edges whitish and slightly crenulate; *stipe* 7–9 cm. long, 1–1.5 mm. thick, equal, with a narrowed stuffed tubule,

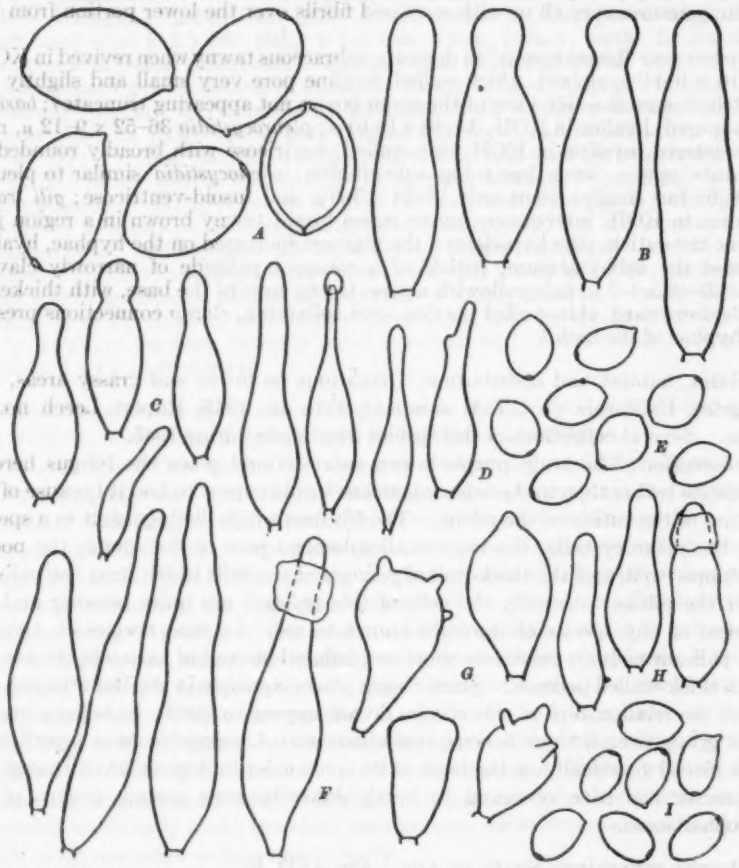

Fig. 4. *Psilocybe Leechii:* A, spores; B, pleurocystidia; *C*, four cheilocystidia. *P. sphagnicola: D*, cheilocystidia, *E*, spores. *P. washingtonensis: F*, pleurocystidia; *G*, cheilocystidia of type 2; *H*, cheilocystidia of type 1; *I*, spores.

rather tough, surface covered by a dense clay-colored fibrillose covering, fibrillose-pruinose near the apex, base dark rusty brown beneath the fibrils.

Spores 5.5–6.5 (7.5) x 4–4.5 (5) μ, bright purple-brown in water mounts of fresh material, dull cinnamon brown when revived in KOH, smooth, some slightly angular and many quite ventricose in face view, ellipsoid to slightly inequilateral in side view but not appreciably flattened, apex truncate but pore small; *basidia* four-spored, 17–21 x 5.5–6.5 μ, hyaline in KOH; pleurocystidia

none seen; *cheilocystidia* forming a sterile band on gill edge, narrowly fusoid-ventricose to almost aciculate (26) 30–40 x 4–8 μ, walls thin, hyaline and usually flexuous in the narrowed portion, apex subacute to acute; *gill trama* more or less parallel, the hyphae dark rusty brown in KOH from an incrusting pigment; *pileus trama* homogeneous beneath a thin hyaline gelatinous pellicle of narrow (2–4 μ) hyphae, the hyphae of the flesh proper dark rusty brown in KOH, the pigment incrusted on the walls (pale brown when single hyphae are isolated), cells 6–15 μ in diameter, clamp connections present.

Habit, habitat and distribution: Single on sphagnum, Rees' Bog, Burt Lake, Cheboygan county, Michigan, June 5, 1935, A. H. Smith 1280-type.

Discussion: The distinctive features of this species are its habitat, small spores, somewhat viscid pileus, argillaceous veil, and long slender stipe. Its habit is similar to that of *Omphalia Gerardiana* Peck, only one fruiting body is found on a moss plant. The fungus appears to be closest to *P. polytrichophila* Pk. from which the characters of the veil readily distinguish it. In addition Peck's species should be further distinguished by its odor, though I have never been able to demonstrate a characteristic odor on any of the collections obtained on Polytrichum. There is a distinct difference between these two in the color reaction in KOH when sections of gills and pilei of both species are compared under the microscope. Those of *P. sphagnicola* give a darker brown reaction. From information obtained so far in my study of the American species of *Psilocybe* this difference is important.

Psilocybe washingtonensis Smith sp. nov. Fig. 4; F, G, H, I.

Pileus 1–2 cm. latus, obtuse conicus vel convexus, viscidus, glaber, hygrophanus, obscure vinaceo-brunneus demum pallide vinaceo-brunneus; lamellae latae adnatae demum subdecurrentes, confertae demum subdistantes, obscure vinaceo-brunneae; stipes 3–5 cm. longus, 1.5–2.5 mm. crassus, aequalis, intus pileo concolor; velum griseum; sporae 6.3–7.5 (8) x 3.8–4.5 μ; pleurocystidia 38–56 (64) x 9–12 μ, subventricosa, obtusa; cheilocystidia 26–38 x 7–11 μ vel 18–26 x 10–12 μ, distinctissima.

Pileus 1–2 cm. broad, obtusely conic to convex, not expanding, margin bent in slightly at first but soon straight, glabrous except for a faint marginal fringe from a rudimentary veil, viscid, hygrophanous but opaque when moist, "walnut brown" (deep vinaceous brown) on disc and "wood brown" (dark avellaneous) near the margin, fading slowly on the disc first to a dull cinnamon color and when dried pale pecan brown or more avellaneous along the margin, pellicle separable only in shreds; *flesh* thin, 2 mm. in the disc and tapered evenly to the margin, pliant, "Rood's brown" moist (dark vinaceous brown), pallid tan when faded, odor faintly fragrant, taste bitterish, *lamellae* broadly and squarely adnate and developing a slight tooth in age and then subdecurrent, horizontal, broad, (3–3.5 mm.) at the stipe, close to subdistant, about 24 reaching stipe, 2–3 tiers of lamellulae, evenly "Verona brown" (slightly darker than the pileus); *stipe* 3–5 cm. long, 1.5–2.5 mm. thick, equal, tubular, dark brown within, rather pliant, surface covered with grayish fibrils but color beneath the fibrils at first concolorous with pileus and becoming blackish brown in age at the base or over lower part, attached to wood or sticks by a grayish mat of mycelium.

Spores purple brown in deposit, 6.3–7.5 (8) x 3.8–4.5 μ, smooth, ellipsoid to slightly ovoid, near ochraceous tawny when revived in KOH, apical pore present but small and inconspicuous; *basidia* four-spored, hyaline, 18–24 x 5–6 μ, nar-

rowly clavate to subcylindric; *pleurocystidia* scattered to abundant, 38–56 (64) x 9–12 μ, narrowly fusoid ventricose with a rather long neck and obtuse to subacute apex, smooth or with mucilage adhering to the apex or neck, thin-walled, hyaline in KOH, the walls often flexuous above the ventricose portion; *cheilocystidia* of two types, the first type fusoid-ventricose with obtuse to subacute apices, 26–38 x 7–11 μ, often with adhering mucilage, hyaline in KOH, thin-walled and not proliferated, the second type broadly clavate to capitate, 18–26 x 10–12 μ, hyaline in KOH but more highly refractive than the ventricose type, mucronate or studded with two or more obtuse protuberances over the enlarged portion, sometimes occurring as pleurocystidia near gill edge and often more irregular in shape, varying from cylindric with a contorted neck and subcapitate apex to irregularly lobed; *gill trama* dark yellowish brown in KOH, parallel to somewhat interwoven; *pileus trama* homogeneous beneath a thin gelatinous pellicle, the hyphae of the flesh floccose and dark yellowish brown.

Habit, habitat and distribution: Scattered on old rotten conifer wood, Mt. Angeles, Olympic National Park, Washington, Sept 21, 1941, elev. 2500 ft. A. H. Smith 17097-type. A second collection was made at Lake Mills, Sept. 25, and a third at Olympic Hot Springs, Oct. 11, 1941.

Discussion: This is a very interesting species because it demonstrates nicely how the characters of the genera of the Strophariaceae intergrade. In *P. washingtonensis* the spores are truly purple-brown when fresh, but in other respects the fungus is very similar to *Kuehneromyces vernalis*. This is particularly evident in the cheilocystidia. The characters which distinguish the species from other *Psilocybes* are the slightly viscid pileus, the two types of cheilocystidia, the pleurocystidia and the small ellipsoid spores. *Psilocybe ferrugineo-lateritia* Vogl. appears to be close to *P. washingtonensis*, but it is described as moist (not viscid), as occurring on mossy soil, and as having much brighter colors.

THE LYMPHOCYTES OF THE BLOOD*

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Blood may be described best perhaps as the "unifier of body metabolism". The plasma offers nothing for the histologist save when it clots, but for the physiologist and the biochemist, the plasma is very important and exceedingly complex, for through it the metabolic unification is chiefly carried out.

Of the corpuscles, only the red blood corpuscles, the erythrocytes, play a significant role in the metabolic unification: by virtue of their content of hemoglobin, they are oxygen carriers, meeting thus that fundamental requirement of metabolism. The erythrocytes of man and mammals are not cells although they are derived from cells with a loss of the nucleus. The leucocytes, on the other hand, are nucleated cells, possessing in each of the five groups customarily recognized distinctive structural features. They all possess the power of ameboid movement whereby, presumably at least, they can escape from the blood channels into the connective tissue. The leucocytes are usually regarded as "defense cells," as early maintained by Elias Metchnikoff, although that necessary corollary, the power of phagocytosis, is clearly exhibited only by the monocytes and the polymorphonuclear neutrophiles. In the connective tissue, but rarely in the blood, other large phagocytic cells, the macrophages, are encountered. Defense reactions through the mediation of certain specific proteins of the blood involve the plasma rather than the corpuscles, although it is possible that the lymphocytes are a source of antibodies (antitoxins), as will be noted later.

Whatever the part, if any, that lymphocytes may play in bodily defense through immunity reactions, it seems clear that they do not directly destroy bacteria, for they typically lack the power of phagocytosis, even though they are ameboid. The typical lymphocyte (i.e., the small lymphocyte) possesses a very scanty cytoplasm, but in all lymphocytes, contrasting with other leucocytes, the cytoplasm is basophile; that is, under the proper conditions it takes a basic (nuclear) stain. What substances or conditions determine this staining reaction is obscure, but it may be pointed out that cytoplasmic basiphilia is, in general,

* This communication is based upon a lecture given by Professor Kingsbury before the Journal Club of the Department of Zoology, University of North Carolina, November 29, 1943. During the latter part of 1945 I asked Professor Kingsbury if he would give me for my files a copy of the notes upon which his lecture was based. In response to my request, with his characteristic generosity and impulse for thoroughness, he set to work to revise his review of the lymphocytes and bring it up to date. He completed this revision in February, 1946, and turned the manuscript over to me shortly before the beginning of the illness that resulted in his death July 8. Although the paper was not written for publication, it seems that so good a review written by one whose original contributions have been so considerable should be made available to students of blood. I have done a minimum of editing.—W. C. George, Department of Anatomy.

characteristic of 'embryonic' cells. This fact, together with the fact that within the bone marrow, where the granular leucocytes are formed, the primary or formative cells from which they are derived possess a basophile cytoplasm, is significant. It has led to a number of interpretations—and also to controversies. It has been suggested: (a) that the lymphocyte is essentially an embryonic or undifferentiated cell, and hence (b) can give rise to a number of differentiated cell types; (c) that it is, or represents, the primitive blood cell (Weidenreich, 1911), and that (d) the stem cell of the granular leucocytes, the myeloblast, is indistinguishable from the 'lymphoblast'. Much effort has been expended by Downey (1927, 1938) and by others to determine in how far the myeloblast conforms in nucleus and cytoplasm to the structural pattern of the lymphoblast. Much work has been done to determine the correctness or incorrectness of such generalizations as the above, and hematologists may usually be placed in one of three groups*—Monists (unitarians), Dualists, or Trialists—depending upon their recognition of one, two or three distinct and distinctive lines of proliferation for the leucocytes.

Although in lower vertebrates (e.g., frog; Jordan, 1919) the lymphocyte of and within the blood may apparently change to other leucocytic types, in man and mammals this is not the case; the granular leucocytes come from the bone marrow tissue. The lymphocytes are generally derived from lymphatic tissue, most of them (it would seem) entering the blood with the lymph and not passing in any numbers directly into the blood, and not from the bone marrow tissue as do the granular leucocytes, according to the accepted interpretation. Such apparently separate origins for the lymphocytes and for the granular leucocytes early established (Ehrlich, 1898) the dualistic theory still generally accepted by most clinical hematologists as correct, although the problem of the monocyte induced some (e.g., Schilling, 1919) to support a trialistic interpretation.

The lymphatic tissue of mammals as the main source of the lymphocytes of the blood is found in three groups of places: (1) within lymphatic nodes (so-called lymph glands), composing the larger part of their mass; (2) subepithelial lymphatic tissue, within and/or under the connective tissue (tunica propria) of mucous membranes, either in a diffuse form or as dense accumulations such as tonsils and the Peyer's Patches of the intestine; (3) splenic lymphatic tissue investing (in its external sheath) the terminal branches of the splenic artery. The lymphatic nodes occur in the course of larger lymph vessels, interpolated essentially as filters in the course of lymph vessels from their beginnings in the body to their opening(s) into the veins. The lymphatic tissue of the second group is associated only with the *beginnings* of lymph channels, while in the spleen (group 3), the lymphocytes rather directly pass into the blood.

The lymph vessels leaving the lymphatic nodes, as well as those from lymphatic tissue structures of the second group, are frequently quite filled with lymphocytes; and the number reaching the blood by way of the lymph appears

* Bloom, *The Handbook of Hematology* (Editor, Hal Downey), volume 1, pages 416 to 435, gives an excellent account of the theories of hemopoiesis. Thirteen schemata illustrate the different interpretations.

to be great. It is estimated that the number entering the blood directly and those poured in daily with the lymph is two or three times the number normally present in the blood at any one time. Many lymphocytes must therefore disappear from the blood, and the problem thus presented is a crucial one.

Three possibilities as to the fate of the lymphocytes of the blood present themselves: (1) they degenerate within the blood, (2) they transform within the blood to other blood cell types, or (3) they migrate into the surrounding connective tissue where again they may accumulate, degenerate, transform to other cell types, or migrate farther onto a free surface. All of these possibilities have been considered, and some of them may be briefly noted. Within the blood a degeneration of lymphocytes has not been convincingly shown, nor in mammals has a transformation to other cell types been demonstrated, although under certain experimental conditions the lymphocytes of the thoracic duct lymph have been induced to change to granular leucocytes (Bloom, 1937). Within the connective tissue, after migration from the blood, all of the several possible fates may exist; but demonstrable proof is difficult. It has been several times claimed (Jordan and Speidel, 1923; Yoffe, 1933) that within the specific connective tissue of the bone marrow lymphocytes from the blood change to erythroblasts, eventually becoming red blood corpuscles. That lymphocytes from the blood migrate onto the free epithelial surfaces of the body was maintained by Bunting and Huston (1921). Their work had particular reference to the intestine, and they suggested that on the surface lymphocytes might adfix or neutralize bacterial toxins, serving thus a protective function. It is true that numerous lymphocytes may be found on the surface of the intestinal mucous membrane, but the abundance of the lymphatic tissue there present suggests rather a local origin of such cells—a source supported by the histological evidence.

It is an interesting fact that whereas in the stomach and intestine the free cells found on the surface are almost exclusively lymphocytes, in the upper reaches of the digestive tract, lined by stratified squamous epithelium—the mouth and oro-pharynx—the cells on the surface, the so-called "salivary corpuscles", are of a variant character. While certain of them are lymphocytoid, perhaps the majority are granular; and many possess polymorphous nuclei and resemble the polymorphonuclear neutrophiles of the blood. Their interpretation has led to divergent views. For example, Weidenreich (1908), among others, considered the salivary corpuscles as transformed lymphocytes and a substantiation of his view that the lymphocyte (lymphoblast) is the parent cell type for all granulocytes wherever formed. A number of investigators presented a different interpretation; namely, that the predominant cell among the salivary corpuscles is the polymorphonuclear neutrophile from the blood. Thus, Isaacs and Danielian (1927), in the most recent consideration of the problem of the salivary corpuscle, suggest that, just as Bunting and Huston indicated that lymphocytes from the blood were "excreted" into the intestine, so in the mouth, neutrophile leucocytes are eliminated from the blood "in the general regulatory mechanism which tends to keep the blood elements within certain numerical limits." However, as the lymphocytes within the intestine may be adequately

accounted for as of local origin, so it seems possible, or even probable, that similarly the salivary corpuscles may be of local origin, many of them from lymphocytes of the lymphatic tissue, which is abundantly present in the oral and pharyngeal regions.

Among the salivary corpuscles are a number of mononuclear granular leucocytes quite like the myelocytes of the bone marrow, which, by accepted evidence, transform to polymorphonuclear neutrophiles of the blood. From the time of Ehrlich to Isaacs and Danielian these granular mononuclear cells of the saliva have been regarded as essentially myelocytes. Weidenreich, of course, considered them as such, giving rise to the polymorphonuclear forms among the salivary corpuscles, and themselves derived from lymphocytes. Because myelocytes are absent or scarce in normal blood, some investigators who believed that the polymorphonuclear salivary corpuscles were neutrophile leucocytes from the blood, interpreted the transformative sequence as in an opposite direction; that is, that the polymorphonuclear cells became mononuclear—a reversal of the sequence found in the bone marrow. It may be said that several experimental workers have found that under certain conditions such a transformation may take place, as well as a transformation in the reverse direction. In the crypt of the cat's palatine tonsil, both mononuclear and polymorphonuclear cells are found; and it seems to me that the evidence indicates that the latter come from the former. This does not necessarily mean that such polymorphonuclear cells are, or are the equivalent of, the similar leucocytic cells of the blood; they may be the expression of a type of degeneration. The peculiar nuclear form characteristic of the polymorphonuclear leucocyte of the blood itself requires explanation. But we have been drawn away from the problems of the lymphocyte.

We may now consider briefly the accumulations of lymphocytes (or lymphocytoid cells) in the connective tissues. These may be small groupings of few cells or quite massive concentrations which are objects of interest, particularly to the pathologist. Such accumulations are commonly regarded as the expression of an intense migration from the blood, although, not usually at least, interpreted as a partial expression of a "general regulatory mechanism which tends to keep the blood elements within certain numerical limits," as did Isaacs and Danielian in their attempt to account for the salivary corpuscles. Rather does the pathologist accept the presence of lymphocytes in the connective tissue as the expression of a reaction to local abnormal conditions, such as a low-grade or chronic inflammatory reaction, the lymphocytes coming from the blood. Other cell types may appear at an inflammatory focus, and we need not consider the complexities of the interpretation. Concentrations of lymphocytes may occur in many, or most, organs and are often spoken of as "small (round) cell infiltrations". This is an old term and implies that the cells have come from elsewhere, presumably from the blood, although it is not always or often possible to determine such a source, and the possibility of a local origin must be considered. Again, frequently there is no clear indication of inflammation, and this increases the difficulty of understanding the presence of the lymphocytes.

Nevertheless, the lymphocytes are perhaps generally thought of as "defense cells" of obscure function.

Two specific instances of lymphocytic accumulation may be noticed: the *first*—the lymphocyte and the fate of transplanted tissues or organs. The following are the well established general results of such transplantation: 1. "Autotransplants" or grafts (that is, transplants to another part of the body of the same individual) will "take", live and may grow, provided that the region permits the establishment of an adequate blood-vascular supply. 2. If the transplant is to another individual of the same species, an "homoiotransplant", it ultimately fails; large numbers of lymphocytes appear in the immediate environment and penetrate the transplant, which is ultimately absorbed. There is usually also a distinct reaction on the part of the surrounding connective tissue of the host. 3. In the case of a "heterotransplant" (to a host of a different species), the connective tissue of the host reacts strongly, tending to encapsulate the transplant and destroy it. The lymphocytic reaction is slight or lacking, but polymorphonuclear leucocytes (sic) appear, frequently in large numbers. Usually there is also an increase of the polymorphonuclear leucocytes within the blood. In the case of homoiotransplants, similarly, the local accumulation of lymphocytes is generally accompanied or followed by their increase within the blood. The above generalizations as to the fate of transplants are largely based upon the work of the pathologist, Leo Loeb, who for over forty years has devoted much of the research of himself and his associates to the problem. By transfers in animals between offspring of the same liter, brother-sister ("syngenesiotransplants") or within closely in-bred stock, it became evident that the problem is part of the larger problem of individuality, for it is evident that the body metabolism (cell metabolism) in each individual is different in certain of its details. Such differences, Loeb terms "individuality differentials," which are of different grades. Many fields of evidence have contributed to the establishment of this fundamental fact, and to this broader aspect of his work, Loeb has recently (1945) contributed a book which carries us far beyond the specific problem of the lymphocytes and their accumulation within the connective tissue; indeed, Loeb was less interested in the lymphocyte as such. He offers but little evidence of the nature of the substances from the transplants which attract lymphocytes; still less does he explain how the lymphocytes effect the destruction of the homoiotransplant.

The *second* selection deals with the lymphocyte and cancer. The pathologist frequently encounters within the stroma of tumors or in the immediate neighborhood, accumulations of lymphocytes. This is particularly true of cancers (carcinomata). It is stated that this is especially true of slow-growing cancers, whereas in rapidly growing, malignant cancer, lymphocytes are less in evidence or are lacking. As have so many experimental pathologist, Loeb transplanted tumors under autogenous, homoiogenous, and heterogenous conditions. The results of such tumor transplantations are well presented in the book referred to above. Loeb concludes that "in principle, the host reacts in a similar way against normal tissues and against tumors," although secondary factors, such as

increased growth momentum, may induce certain modifications; but the lymphocytic reaction is essentially the same. Other cancer workers, however, particularly Murphy and his collaborators, have considered the relation of lymphocytes and tumor.

To substantiate his thesis, Murphy carried out a number of well planned and executed experimental procedures, which are well summed up in his latest publication in this field (1926). A detailed presentation of his results cannot well be included here, for they belong to a consideration of the cancer problem. However, he found that the implantation of the tumor induced an accumulation of lymphocytes about the implant. There followed an invasion of the tumor graft. Usually, also, there was an accompanying or following reaction by the connective tissue of the host. The local lymphocytic reaction was frequently accompanied (or followed) by an increase of the lymphocytes in the blood, due to a stimulation of the lymphatic tissue, the source of the blood lymphocytes, although in some instances the local lymphocytic reaction was not accompanied by a general lymphocytosis. Just how the lymphocyte produces its effect on the cancer is not clear*, although it is obvious that substances are given off (by the implant) which reach the general circulation and stimulate lymphatic tissue in other parts of the body. Murphy saw no evidence that antibodies were produced by the lymphocytes; however, the problem of immunity to cancer seems to be involved. Loeb (1945, p. 418), it may be noted, gives a concise summary of the contributions of Murphy.

It is perhaps the general interpretation of hematologists that lymphocytes in the general connective tissue are migrants from the blood; both Loeb and Murphy apparently infer such a source for the lymphocytes accumulated in and about grafts, but since their experiments offered no direct proof, the question of source was not adequately discussed. Doubtless many lymphocytes in the connective tissues are from the blood. Since, however, leucocytes are not formed in the blood but come from specific forms of connective tissue, more particularly the myeloid or bone marrow tissue and the lymphoid or lymphatic tissue, it is possible or even probable that areas of lymphocyte differentiation may arise atypically in many regions. Murphy, indeed, comments that "small deposits (of lymphoid tissue) are scattered through most of the organs and tissues of the body." Bloom (1942), in his most recent consideration of the lymphocyte, offers the following new comments: (p. 59) "The smaller lymphoid cells are identical with the non-granular leucocytes of the blood. This does not mean that they have all emigrated from the blood vessels in the adult organism. The cell lineage of many of them originated in the embryonic mesenchyme and stayed there"; (p. 82) "New foci of lymphatic tissue and even lymph nodes can develop in any part of the loose connective tissue in the adult organism. The elements of the stroma and the lymphocytes in such cases develop from the ubiquitous undifferentiated mesenchymal elements of the adult connective tissue."

* Murphy, 1926, p. 158: "Precisely what the mechanism is which determines whether or not a local reaction is to take place about a cancer graft and how the lymphocyte exerts its influence on the cancer cell are points on which we have been able to gain no light".

In what may be termed the 'typical' lymphatic (lymphoid) tissue, earlier referred to as the main source of the lymphocytes of the blood, localized centers of lymphocytopoiesis arise—the "lymphatic nodules." As they enlarge, there develop central clear areas with larger, less compactly massed cells. In these areas mitosis is usually more abundant, hence these areas are "germinal centers." The sequence of the proliferation within the germinal center produces large, medium and small cells, usually designated as lymphocytes, although some, at least of the larger forms, may deserve the name of lymphoblasts. The connective tissue foundation of the nodule is a reticular tissue whose cells (reticulum cells) are the ultimate source of the lymphocytes. The early or embryonic nodule lacks a clear center, is solid, and consists mainly of small cells, most of them identifiable as small lymphocytes or lymphocytoid cells. Older, post natal, nodules with clear centers usually show, within the center, evidences of cell- and nuclear-degeneration and the presence of macrophages; hence a number of workers regard the clear center area as marking a *reaction center* rather than a germinal center, or possessing a different significance at different times, for the lymphatic nodule is not a fixed structural unit but is labile and subject to change. The evidence indicates that nodules may come and go. They are best thought of as localized centers of proliferation leading mainly to the formation of small lymphocytes. The factors determining either the proliferation or its localization are not as yet clear.

The reason for introducing a brief discussion of typical lymphatic tissue with its nodules is that not infrequently in the other accumulations of lymphocytes, particularly within certain glands, lymphatic nodules occur, often ill-defined, it is true, but with apparently typical germinal centers. This is especially true of the thyroid gland, where the presence of lymphatic tissue is quite characteristic of certain diseases (Graves' disease; Hashimoto's disease). If the lymphatic nodules with their clear centers are regions of localized lymphocytic proliferation in the typical lymphatic tissue, there seems to be no reason for not so interpreting them when they occur in less typical accumulations. A local origin of the lymphocytes would be thus supported. Unfortunately, a detailed histological analysis of such clear areas as germinal centers is rarely made; however, Schilling (1945), in perhaps the latest consideration of the lymphocytes within the thyroid gland, describes the "germinal centers [as] composed of larger lymphocytes and reticulum cells with their mitotic figures." The connective tissue is not described by him; it would be of interest to know whether in such accumulations of lymphocytes, reticular tissue is the foundation as in typical lymphatic tissue. The reticular fiber seems to be a more embryonic form and hence is encountered in areas of free cell proliferation and also as the primary form in the development of the collaginous fibers. The argyrophil fiber network and collaginous fiber bundles are, therefore, not two distinct forms of connective tissue, but intergrade.

It may be recalled that both Loeb and Murphy interpreted the local reaction of the host to a transplant as of double significance, consisting of a lymphocytic reaction and of a reaction on the part of the host connective tissue. Loeb particularly emphasized that, in general, in the reaction to less "foreign" tissue (as in

the case of homoiotransplants), the lymphocytic reaction predominates, whereas in the case of the extremely foreign tissue (the heterotransplant), the reaction on the part of the host connective tissue prevails, leading to a fibrosis and encapsulation with the resulting destruction of the transplant. When Loeb first published (1915) a general statement of his results, I ventured to suggest that the two seemingly distinct reactions might well be two phases or aspects of a single response on the part of the host connective tissue. It still seems to me that this point of view may be of value in the comprehension of many structural conditions which the pathologist must explain, as well as in the full analysis of such distinctive structural expressions as tonsils and thymus. The corollary of such an interpretation would be that many accumulations of lymphocytes in the connective tissue would be the result of local proliferation rather than due to a migration of lymphocytes from the blood. Such areas would structurally correspond to atypical lymphatic tissue, "proliferating", as Maximow (1932) expressed it, the "ubiquitous lymphoid cell."

The word *function* I have several times described as a *pattern* term rather than a *process* term; yet the physiologist ever seeks to ascertain the functional significance of any organ, tissue, or cell group—and quite rightly, for in the complex of conditions under which the body exists, in its responses it must maintain a unity of action and display a functional adaptation to the conditions. The lymphocyte, however, presents exceptional difficulties. Drinker and Yoffey (1941), in an extensive and detailed investigation of the lymphatic system, could find no clear function for the lymphocyte, and, hence, they suggest "that the lymphocyte may be important not for what it does but for what it is. Or, in other words, the lymphocyte itself may not possess any important functions, but it may be capable of becoming transformed into other cells which do." Earlier in this talk, I pointed out that the lymphocyte in its structure suggests an undifferentiated cell, essentially embryonic. Under certain conditions the lymphocyte may, indeed, change to other cell types: monocytes of the blood and of the connective tissue; macrophages and (at least, indirectly) fibroblasts (fibrocytes); so-called polyblasts; also, granular leucocytes. It should be pointed out that the conditions under which such transformations can be induced are abnormal, experimental or pathological. The lymphocytes of the blood appear to be of indifferent character. There is no evidence that in man and mammals the lymphocytes in the blood change to another cell type, unless, it be to monocytes; nor is there adequate evidence that, migrating into the specific connective tissue of the bone marrow, they give origin to any of the cell types there occurring. Their fate after migrating into the general (loose) connective tissue of the body is problematic and their function, if any, obscure.

Lymphatic tissue, the main source of the lymphocytes of the blood, may be described as a seat of cell proliferation which leads finally to the production of innumerable small cells, the small lymphocytes or lymphocytoid cells, a very peculiar cell type. The nucleus is very chromatic, the chromatin particularly massed in clumps next the nuclear membrane. The basophile cytoplasm is so scanty that it is often indistinguishable; indeed, the proliferation that leads to

the formation of the small lymphocytoid cell suggests more a device to increase nuclear substance rather than a growth through mitotic cell division. Although the small lymphocyte, usually, at least, possesses two centrioles, it is doubtful if it, as such, ever divides. The evidence, however, indicates that under certain conditions, in tissue cultures, in the lymph of the thoracic duct, and also doubtless in the connective tissue, the small form of lymphocyte may increase its cytoplasm and divide, although the cytological details have been inadequately determined.

A specific function for the small lymphocyte with its mere film of cytoplasm appears doubtful, for it is in the cytoplasm of cells that the processes take place, upon which their functional significance rests. Nevertheless, it is usually assumed that a function for the lymphocyte exists. It has been suggested that the lymphocyte plays a part in the digestion of lipids; that it neutralizes bacterial toxins or toxic end products of metabolism and possibly such substances from tissue necrosis. More specific is the theory that the lymphocyte or lymphatic tissue is the source of antibody in immunity reactions. Both Loeb and Murphy entertained this possibility but could furnish no evidence; more recently experimental evidence has been submitted in its support (Ehrich and Harris, 1942, 1945; Kass, 1945; Dougherty, 1945; Dougherty and White, 1945). The evidence applies less directly to the small lymphocyte than to the lymphatic node, where cells with abundant cytoplasm, including the so-called reticulo-endothelial cells, also occur. In this connection, it may be noted that within lymphatic tissue and in efferent lymph channels lymphocytes shed cytoplasmic fragments into the lymph (Downey and Weidenreich, 1912, and others). No chemical analysis of such cytoplasmic droplets apparently has been made, but it well may be that they are largely protein. The best known instance of such cytoplasmic fragmentation is found in the megakaryocyte of the bone marrow, which is quite generally believed to be the source of the blood platelets. Schuster (1940) has pointed out that other cells of the blood cell series (myeloblasts, promyeloblasts, macrophages) also exhibit the same phenomenon. Whether this cytoplasmic reduction in the lymphocyte links in with the scantiness of cytoplasm in the small lymphocyte is not clear; nor does there seem to be any evidence that this phenomenon has significance as the source of the antibodies in immunity reactions, although such a hypothesis is suggestive.

From this survey of the lymphocyte, it is clear that this peculiar cell still presents problems. It is particularly the typical or small lymphocyte which calls for further elucidation. The cytologic details of the mitosis that produces it are inadequately known; nor are the implications of its peculiar structure clear. We have seen how the problem of the lymphocyte is linked with that of the general connective tissues and more specifically with the broader problems of the immunologic reactions and with cancer. It is particularly from the physiologic and biochemical aspects that basic facts are lacking. Details from the histologic and histogenetic side are still needed, especially in the occurrence of the lymphocyte in the connective tissues and the part that it plays, or may play, in normal and pathologic processes.

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SMOOTH PATCH, A BARK DISEASE OF OAK

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Twelve Text Figures

INTRODUCTION

Smooth patch involving the bark of white oak, *Quercus alba* L., and post oak, *Q. stellata* Wang., has long been known throughout the deciduous forest regions of the eastern United States. Bark lesions are so universally present on white oaks that foresters use the presence of the disease as a means of identifying them. By forest pathologists the disorder has been variously designated as "smooth patch," "white patch," and "smooth bark" (Baxter, 1943; Boyce, 1938). It is important insofar as it indirectly affects the health of the tree by reducing the bark thickness and thus decreasing protection against desiccation, mechanical injury, and wood destroying fungi and, when present on ornamental or shade trees, it makes them somewhat unsightly (Tehon and Jacks, 1933).

Presumably first mention of smooth patch was made by Craighead (1923), who noted that the larvae of Encyclops, an insect belonging to the Cerambycidae or long-horned beetles, occur oftentimes in numbers on certain limited areas of the outer dry corky bark of *Quercus alba*, Liriodendron, Acer, Castanea, Juglans and Nyssa, causing the bark to flake off after a time and to appear smooth. He also found Microclytus, an insect of the same group and possessing a similar habit, associated with smooth patch lesions.

Ten years later, Tehon and Jacks (1933) noted a bark disease of white oak in Illinois which they described as being manifest as a sloughing off of the outer and corky regions, leaving irregularly circular patches of light-colored, smooth-surfaced, sunken bark. These patches occur on the trunk and larger branches and may be so extensive as to involve a large proportion of their surface. They attributed the disorder to *Aleurodiscus oakesii* (B. and C.) Cooke, a basidiomycete in the family *Thelephoraceae*, because they found its fruiting bodies constantly present on smooth patch lesions and completely absent from the normal bark. Soon after Tehon and Jacks' report was published, Craighead (1933), in a letter to the editor of the *Journal of Forestry*, called attention to his own previous observations and concluded that further observations were desirable in order to determine whether both factors—Aleurodiscus and Encyclops—were responsible for the characteristic bark lesions on white oak.

Similar bark lesions (Fig. 1) are also very common in the vicinity of Durham, North Carolina, where the disease appears on both white oak and post oak, and where a species of Corticium is of common occurrence on the smooth

[1] I am grateful to Dr. F. A. Wolf, Dr. D. H. Linder, Prof. H. S. Jackson, Dr. E. S. Luttrell, and Dr. Ruth M. Addoms for help in connection with this study and in the preparation of this report.

Fig. 1. Smooth patch lesions on *Quercus stellata*.

patch lesions. To determine the possible causal relationship of this Corticium to the disorder, a survey of its incidence in the immediate environs of Durham was undertaken. Moreover, attempts were made to isolate the Corticium from affected bark, and *in vitro* experiments were conducted to determine its ability to disintegrate oak bark.

METHODS AND MATERIALS

The rate of development of smooth patch lesions was studied by repeated observations on certain affected trees. To do this, the margins of lesions on these trees were marked at the beginning of the observations.

Various fungi were isolated from diseased bark throughout the year by making tissue plantings on poured plates of 3 per cent malt agar.

The Corticium considered herein and described subsequently was isolated by suspending its fruiting bodies over malt agar plates and allowing the basidiospores to be shed onto the agar. The spores germinated promptly, and gradually a fungus mat developed on such plates.

Four species of fungi from among those isolated were employed in experiments designed to determine their ability to decompose oak bark *in vitro*. These four species included the Corticium, *Aleurodiscus oakesii*, believed by Tehon and

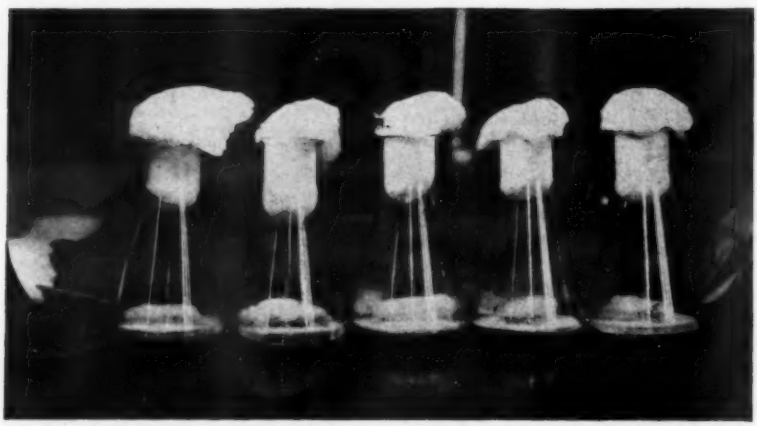

Fig. 2. Flasks containing bark cultures of *Corticium maculare* n. sp.

Jacks (1933) to be the cause of smooth patch, and *Trichoderma viride* Pers. and Xylaria sp., the latter two of which were frequently isolated from tissue plantings of diseased bark. Four sets of cultures, involving these four different species, were made. Each set consisted of twenty-five bottles or flasks containing 3 per cent malt agar medium emplanted with one or another of the four fungi. After the fungi had grown to the extent of forming a large mat, a v-shaped glass rod was placed upon the mat as a support for a block of bark (Fig. 2). These blocks of air-dried white, post, or southern red oak varied in size, but the average was about 2 x 1 x $\frac{1}{8}$ inches. In preparing the blocks they were sterilized by autoclaving, weighed in a sterile condition, and introduced with aseptic precautions into the bottles or flasks.

Trichoderma and Aleurodiscus were allowed to act on the bark for a period of about eleven months, Xylaria, nine months, and Corticium, six months. The

first sets of cultures of Corticium and Xylaria became contaminated and were therefore discarded, and new sets were made. For this reason there is lack of accord in lengths of time the different fungi were allowed to act. All cultures were incubated in the laboratory at room temperature. Prior to the final weighing, the mycelium was brushed off the bark blocks, after which they were autoclaved and then oven-dried at 30°C. for eight days.

To determine the structure of the hymenophore of the Corticium and the disposition of mycelium within the bark, appropriate materials were fixed in formalin-acetic-alcohol. Later the tissues were dehydrated, imbedded in paraffin, sectioned and stained with Heidenhain's iron haematoxylin.

Since bark or corky tissue is a cellulose-lignin-suberin complex, the Corticium was grown on special media containing either lignin, pectin, fat, or cellulose, to determine whether it can produce enzymes capable of utilizing these substances. The lignin medium was made by mixing agar, water and enough lignin powder to give a slight brown color. Lignin utilization was to be indicated by a zone of clearing in the medium around the Corticium colony. Pectin agar was prepared from commercial Certo purified by repeated precipitation with alcohol (Wolf, 1923). Brom-cresol purple or Phenol red were used as indicators. The fat medium—litmus cream agar—, and the cellulose medium were prepared according to the methods of Crabill and Reed (1915).

In seeking to explain why lesions are limited to white oaks, media containing water extractives of black oak bark and of white oak bark were prepared for comparative cultural studies of the Corticium.

RESULTS

As regards extension of white patch lesions, examinations show that they increase in size very slowly. The margin had been advanced radially during a period of six years only 2.84 inches. Vertical extension of lesions, however, was somewhat more rapid than that around the bole.

Trichoderma viride and Xylaria sp. were the fungi most frequently isolated from diseased bark. Those isolated occasionally from such bark and believed to be of little significance include Nigrospora, Pestalotia, Chaetomium, a yellow Penicillium, Aspergillus, Mucor, Rhizopus, *Phycomyces nitens* (Ag.) Kze., *Monilia sitophila* (Mont.) Sacc., and two slime molds, Fuligo and Stemonitis.

Each of the four species of fungi artificially cultivated on blocks of bark was found capable of inducing a decrease in weight. The average decrease caused by the Corticium during the six-months period was 8 per cent; that by Aleurodiscus during eleven months was 23.8 per cent; that by Xylaria during nine months was 7.6 per cent; and that by Trichoderma during eleven months was 14.6 per cent. None of them, however, except the Corticium, completely enveloped the blocks. They seemed to be confined to the surface, and the bark was not disintegrated in a manner characteristic of smooth patch, or as was accomplished *in vitro* by the Corticium.

Microscopic examinations of bark invaded by the Corticium reveal areas of disintegrated cells, that appear as pockets. The pockets may be loosely occupied

by hyphae and interspersed intact cells. Manifestly the cells are freed from each other as the result of dissolution of the primary membrane. Such a condition with a fruit body at the surface is shown in Figs. 3 and 4. The hyphae course between the parenchyma after dissolution of the middle lamella, Figs. 5 and 8. Clamp connections are evident when the fungus is grown in culture, Figs. 6 and 9. In figure 10 is shown a cuboidal basidium provided with four slender, incurved sterigmata. Figures 11 and 12 show such basidia and their complement of tiny basidiospores.

By use of the special media it was found that the Corticium was able to produce acid from pectin and from fats, indicating pectic and lipolytic enzyme action. A zone of clearing around the colonies on lignin agar indicated digestion of lignin, but cellulose was not attacked. These findings of enzyme-producing abilities may be employed to interpret the tissue changes noted above from the microscopic examinations.

The media containing extractives from oak bark supported growth of the Corticium. The growth was much less vigorous and profuse on media containing black oak bark however, than that on white oak bark.

IDENTITY OF THE CORTICIUM

The species of Corticium always present on smooth patch lesions was at first thought to be *C. scutellare* B. and C. Specimens were sent for identification to Dr. David H. Linder, Farlow Herbarium, Harvard University, and to Dr. H. S. Jackson, University of Toronto, Toronto, Canada, who has been working on the genus Corticium for about twelve years. Dr. Linder determined the specimens sent him as probably *C. scutellare* but voiced the opinion that it might well be one or another of several species. Concerning the specimens sent him, Dr. Jackson stated that he had spent some time in an effort to find a safe name to apply to the fungus but without success. He expressed the opinion that it might be one of several named species but might better be described as new. He believed further that there were a great many undescribed species of Corticium especially in the South, and that there were probably double the number of species of "Corticium" (sensu Burt) in North America as were included in Burt's monograph. In consideration of the above statements, and of certain structural features of the Corticium, and of its prevalence on certain species of oaks, it was decided to describe it as a new species. The specific name was chosen because of the occurrence of the fungus only in association with the white or smooth patch lesions. A summary of its characteristics follows:

Corticium maculare n.sp.

Fructifications effuse on bark of living white oaks (*Q. alba* L. and *Q. stellata* Wang.), thin, adnate, when mature cracked into minute areolae, 0.33–1.0 mm. in diameter, which flake away from the substratum leaving some white subiculum on the latter; the margin quickly thinning out, not byssoid; friable when dry; color ranging from cream to dark buff. Entire pileus about 0.5–4.0 x 0.3–1.5 cm., 20–170 μ thick, composed of delicate, thin-walled hyphae, 1.8–3.6 μ in diameter, with clamp connections and encrusted with mineral matter in

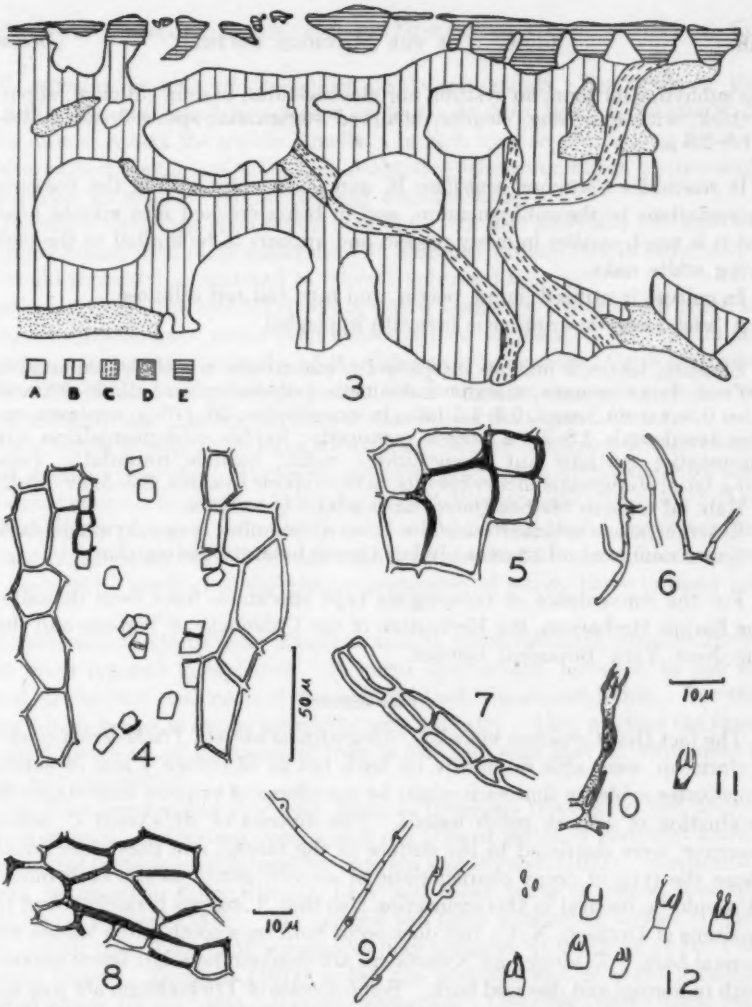

Fig. 3. Diagram of cross section of diseased bark with a superposed fruiting body of *C. maculare*.
A. Pockets partly occupied by hyphae of the fungus.
B. Bark parenchyma.
C. Layers of corky tissue.
D. Partly disintegrated cells.
E. Fruiting body of the fungus.
Fig. 4. Intact cells freed from each other by action of the fungus.
Fig. 5. Parenchyma cells showing the fungus coursing between them.
Fig. 6. Hyphae of *C. maculare* in culture.
Fig. 7. Group of cork cells.
Fig. 8. Intercellular hyphae.
Fig. 9. Clamp connections of *C. maculare* in culture.
Fig. 10. Portion of the hymenium.
Fig. 11. Basidium and sterigmata.
Fig. 12. Group of basidia with sterigmata and basidiospores.

the subhymenial zone; no cystidia nor gloeocystidia; basidia cuboidal, about 3.6 μ thick, with four long, slender, incurved sterigmata; spores hyaline, 3.5–5.5 x 1.8–2.8 μ.

It resembles *Corticium scutellare* B. and C. in color and in the presence of encrustations in the subhymenium, and in being cracked into minute areolae, but it is much smaller in every respect and appears to be limited to the bark of living white oaks.

In culture it utilized lignin, pectin, and fats, but not cellulose.

A brief Latin description is herewith appended.

Effusum, tenue, a matrice inseparabile, maturitate in glebulas minutas 0.33–1.0 mm. latas formans, margine indistincto; pulverulentum; albido-ochraceum; pileo 0.5–4.0 cm. longo, 0.3–1.5 lato; in crassitudine 20–170 μ, contextu ex hyphis tenuissimis 1.8–3.6 μ crassis composito; hyphis subhymenialibus minute incrustatis; cystidiis aut gloeocystidiis nullis; basidiis rotundatis, 4-sporis, 3.6 μ latis; sterigmatis incurviusculis, acutis; sporis hyalinis, 3.5–5.5 x 1.8–2.8 μ.

Hab. ad truncos vivibus *Querci albae* adque *Q. stellatae*.

Externa facie *Corticium scutellare* B. et C. simulat, a quo hymenio, basidio, ac sporo minore et ad truncos vivibus Querci habitato distinguitur.

For the convenience of mycologists type specimens have been deposited in the Farlow Herbarium, the Herbarium of the University of Toronto and that of the New York Botanical Garden.

DISCUSSION

The fact that *Corticium maculare*, *Aleurodiscus oakesii*, *Trichoderma viride* and Xylaria sp. were able in culture on bark blocks to induce a loss of substance constitutes evidence that each might be considered of primary importance in the production of smooth patch lesions. The mycelia of all, except *C. maculare*, however, were restricted to the surface of the blocks, and they were unable to cause the type of decay characteristic of smooth patch, as has been indicated. It should be recalled in this connection also that *A. oakesii* is rarely found in the environs of Durham, N. C., but does occur both on smooth patch lesions and on normal bark. *T. viride* and Xylaria sp. are common here but occur universally both in normal and diseased bark. Some species of Trichoderma are well known to be capable of decomposing cellulose, and similarly, species of Xylaria of attacking lignin and pectin. Nevertheless, *C. maculare* is herein considered primary in the production of smooth patch and the other organisms of secondary significance. This conclusion is supported by the summarized observations that follow:

(a) *C. maculare*, in the environs of Durham, N. C., is found constantly associated with smooth patch lesions and has never been noted on normal bark.

(b) The white pockets of decay, produced by this fungus *in vitro* correspond with the type of decay in lesions on infected trees. Such localized disintegration of tissues is known to be associated with lignin-utilizing fungi, a capability possessed by *C. maculare*, as has been shown by growth on lignin agar.

(c) *C. maculare* is able to decompose pectic compounds. By virtue of this ability, as established by reaction on pectin *in vitro*, this fungus should be be able to attack the middle lamella. In fact, hyphae are present between the walls of contiguous cells, and intact, free cells occur within white pocket cavities, as revealed by microscopic examinations.

(d) By use of dyes that stain fats it may be shown that suberized cell walls are impregnated with fatty materials. *C. maculare* utilizes fats *in vitro*, and it would therefore be expected to "defat" suberized tissues.

Species of Encyclops and Microclytus, found associated with smooth patch by Craighead (1923), have never been collected near Durham, N. C. From the collection data in Leng's *Catalog of the Coleoptera in America, North of Mexico* (1920, 1927, 1939) the range of species included in these genera seems to be limited to the northern and western portions of the United States and Canada.

The question of why white oaks are attacked and other species of oaks escape attack remains unsettled. *Corticium maculare* grew much more poorly on agar containing aqueous extractives of black oak bark than on agar containing extractives, similarly prepared, from white oak bark. It would seem therefore, that the lack of lesions on black oak bark cannot be ascribed to toxic substances but may perhaps be ascribed to the greater proportion of woody fibers in black oak bark.

The presence of *Aleurodiscus oakesii* on smooth patch lesions in other deciduous forest areas remains unexplained. It seems appropriate, however, to call attention to the fact that none of the invaded bark tissues are living. For this reason a high degree of causal specificity may not exist. Also, whether the cause of smooth patch on other genera of trees is identical with that on white oaks is as yet not established.

Little consideration has ever been given to problems relating to the decomposition of bark or suberized tissues, and the present status of pertinent knowledge remains quite as summarized by Thaysen and Bunker (1927). Apparently suberin, as found in the epidermis, bark and corky parts of plants, was first studied by Chevreul (1815). He termed the fatty substances *cerine*. Gilson (1890) found that these fatty substances may comprise as much as 44 per cent of corky tissues. Zemplén (1913) noted the presence also of a cellulose-like material which did not yield cellobiose octacetate. Councler (1894) found pentosans present. Moreover Thaysen and Bunker (1927) point out that the role of microbes in decomposition of suberin is entirely unexplored. It would appear, since bark that has been shed does not tend to accumulate in large quantities at the bases of trees, that microorganisms must be responsible for its decomposition. Little is known to date, however, about the species of microorganisms involved, of their interdependence, or of the chemical changes they may induce. Such studies are indicated as a desirable next step.

SUMMARY

Smooth patch, or white patch, is a disease of the bark of white oak and post oak which is widely prevalent in the deciduous forest regions of the eastern United

States. It is manifest by decomposition and disintegration of the outer bark in large patches. These patches increase in size very slowly.

The disorder has been reported to be caused by certain long-horned beetles, Encyclops and possibly Microclytus, and also by the thelephoraceous fungus, *Aleurodiscus oakesii*. This study constitutes an attempt to show that in the vicinity of Durham, North Carolina, smooth patch is caused primarily by *Corticium maculare*, herein described as a new species.

Evidence of causal relationship of *C. maculare* to smooth patch rests (a) upon the universal occurrence of this fungus on bark lesions and its absence on normal bark; (b) upon its isolation in pure culture and ability in appropriate tests to utilize lignin, pectin and fats; (c) upon its ability, as shown microscopically, to disintegrate bark *in vitro* in a manner like that of naturally decomposed bark, and (d) upon decrease in bark substance when grown in culture on sterilized bark.

Although some of the other organisms isolated from lesions and from normal bark were able to decrease bark substance in culture, yet none of them is herein regarded as of primary significance in the production of smooth patch.

It is indicated lastly that problems relating to the disintegration of suberized tissues of trees generally should be given consideration.

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A SIZE-FREQUENCY STUDY OF PINUS BANKSIANA POLLEN

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Four Text Figures

In the application of the size-frequency technique for the identification of fossil pine pollen, the curves constructed from fresh pollen or pollen from herbarium specimens have been superposed on those constructed from fossil material (Cain, 1940). Recently an attempt was made to discover how well the present flora around Jerome Bog in Bladen County, North Carolina, is being recorded in the peat now forming. Handfuls of the surface inch or so of peat were collected from several locations near the center of the bog and were examined for pollen. This study included the construction of size-frequency curves for the pine (Buell, 1946). Dry-preserved pollen of none of the pine species on or around the bog yielded a curve that could be superposed upon that obtained from the bog samples; the latter reflected pollen that was much too small. It was concluded that fossilization modifies the grains in such a way that they do not respond to the swelling influence of the chemicals used in the preparation of slides as much as do the herbarium preserved grains. Since the samples came from the center of a large bog which is occupied by *Pinus serotina* Michx. the fossil pollen must have been almost entirely of that species. To verify the results it was decided to turn to a similar study of a species having a grain of very different size and being fossilized under different climatic conditions.

Through the kindness of Dr. T. Schantz-Hansen of the University of Minnesota Forest Experiment Station at Cloquet, Minnesota, surface samples were obtained from "Jack Pine Bog," a bog on the Cloquet Experiment Forest. This is both occupied by and surrounded by a forest of *Pinus banksiana* Lamb. The pollen grain of this species is much smaller than that of *Pinus serotina* and the cold bogs of Minnesota are exceedingly different from those developed under the subtropical climate of southeastern North Carolina. For comparative purposes reference pollen of jack pine was also available. This was furnished by Dr. C. O. Rosendahl who collected three samples from herbarium specimens in the University of Minnesota herbarium and a fourth from cones that had been preserved in formalin.

METHODS

The collection of the surface samples from the bog was accomplished by simply taking handfuls of surface material and placing them in paper bags. They were allowed to dry. Two included peat extending to a depth of four or five inches. Five other samples were moss collections. Of these last, slides were made both from the green, living top of the moss and others were made from the old, dead moss at the bottom.

Both the reference pollen from the herbarium and that from the bog were treated by the acetolysis method (Erdtman, 1943).* After treatment the pollen was stained with safranin and mounted in glycerine jelly. One hundred and fifty grains were measured on each slide. The measurement used was the inside diameter with the bladders lying at each end. This is the same measurement as was used in the study of *Pinus serotina*. The curves in the figures are each based on 150 grains. A mechanical stage was used and all grains encountered lying with the proper diameter parallel with the plane of the slide were measured until 150 grains had been recorded. In tabulating sizes the measurement was taken to the nearest ocular line. The lines were 3.6 microns apart. A magnification of 440 X was used.

RESULTS

When size-frequency curves of the four available collections of *Pinus banksiana* pollen were plotted, two turned out to be exceedingly alike with a "mode" at 13 ocular lines (46.8 microns) (Fig. 1).† The other two collections diverged from this. One of them yielded a curve with a "mode" at 11 ocular lines (39.6 microns) but with a somewhat larger average grain size. The fourth collection proved to have such a considerable proportion of larger grains that the "mode" of the resulting curve was at 14 ocular lines (50.4 microns). This one is the sample preserved in formalin. Cain (1940) published a size-frequency curve based on one collection of jack pine. The "mode" of his curve is at 46.8 microns. But he used the outside diameter rather than the inside length of the grain and in so doing included the thickness of the marginal ridge. Since this ridge is about 3 microns thick his curve is comparable to the curve in Figure 1 which has its mode at 39.6 microns. The true mode for jack pine pollen if samples from a large number of trees were available would very likely lie somewhere above 40 microns.

Such a curve representative of jack pine pollen could be obtained by sampling the pollen rain of one season in the jack pine forest. With this in mind pollen was extracted from the fresh, green parts of mosses and size-frequency curves constructed. These samples though predominantly of very recent pollen, are obviously somewhat subject to contamination both by older grains and by chance grains of other pine species of the region. However, the great preponderance of pollen measured to produce the five curves in Figure 2 must have been shed in the last spring's pollen rain. Four of these five curves have a very definite "mode" at 43.2 microns. The fifth one, represented by the solid line, though it does not diverge much, reflects the presence of somewhat larger grains.

The dead portions of the moss collections just below the green, living parts of the moss yielded pollen that failed to swell as much as that from the living moss.

* The acetolysis method was used so that results would be comparable with previous studies on the size-frequency technique.

† The term mode is placed in quotation marks whenever we are dealing with a modal class rather than the true mode. Since sizes are tabulated to the nearest ocular line the true mode in any case may lie as much as 1.9 microns either side of the modal class.

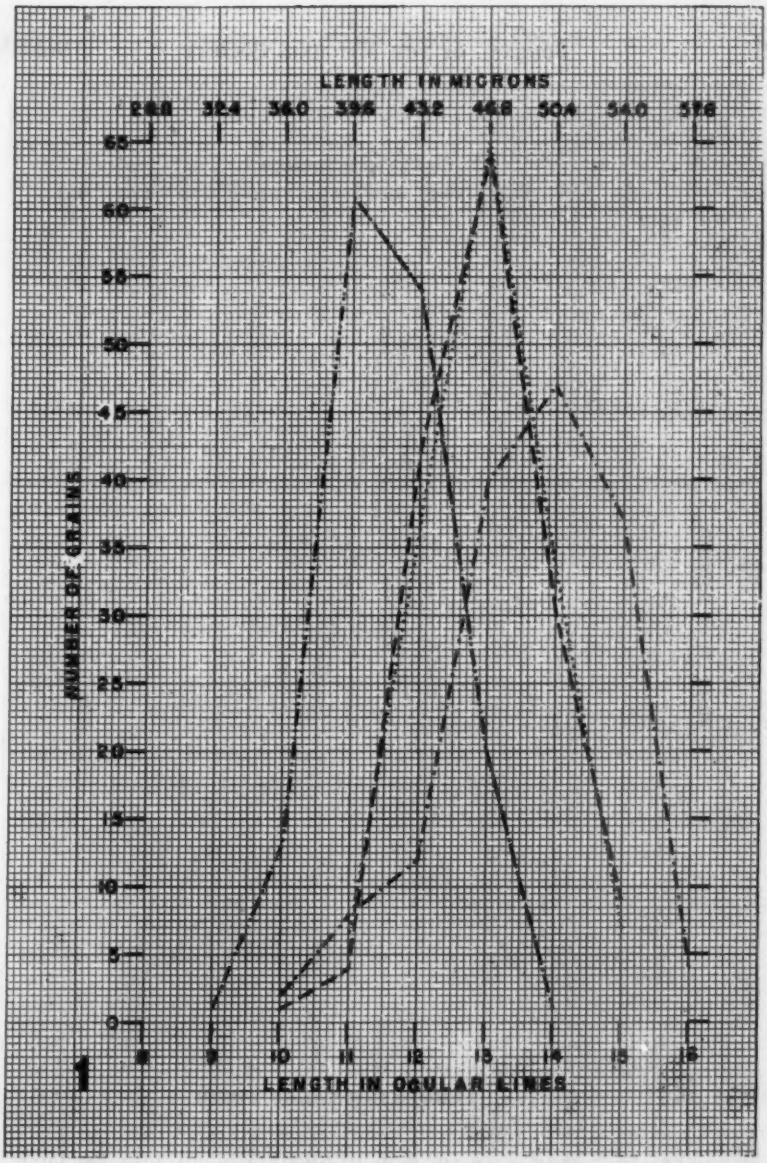

Figure 1. Size-frequency curves of four collections of jack pine. The curve at the right with the mode at 50.4 microns was obtained from pollen preserved in formalin. The others are all from University of Minnesota herbarium specimens as follows: The one at the left with a mode at 39.6 microns—collected in Creek Twp., Pine Co., Minn., 1941, J. Moore No. 14054. Of the other two, that shown by the dashed line is from Red Lake, Beltrami Co., Minn., J. Moore No. 15226, 1942, and that shown by the dotted line is from Hubbard Co., Minn., J. Moore, No. 15180, 1942. Each curve represents the measurement of 150 grains treated by acetolysis.

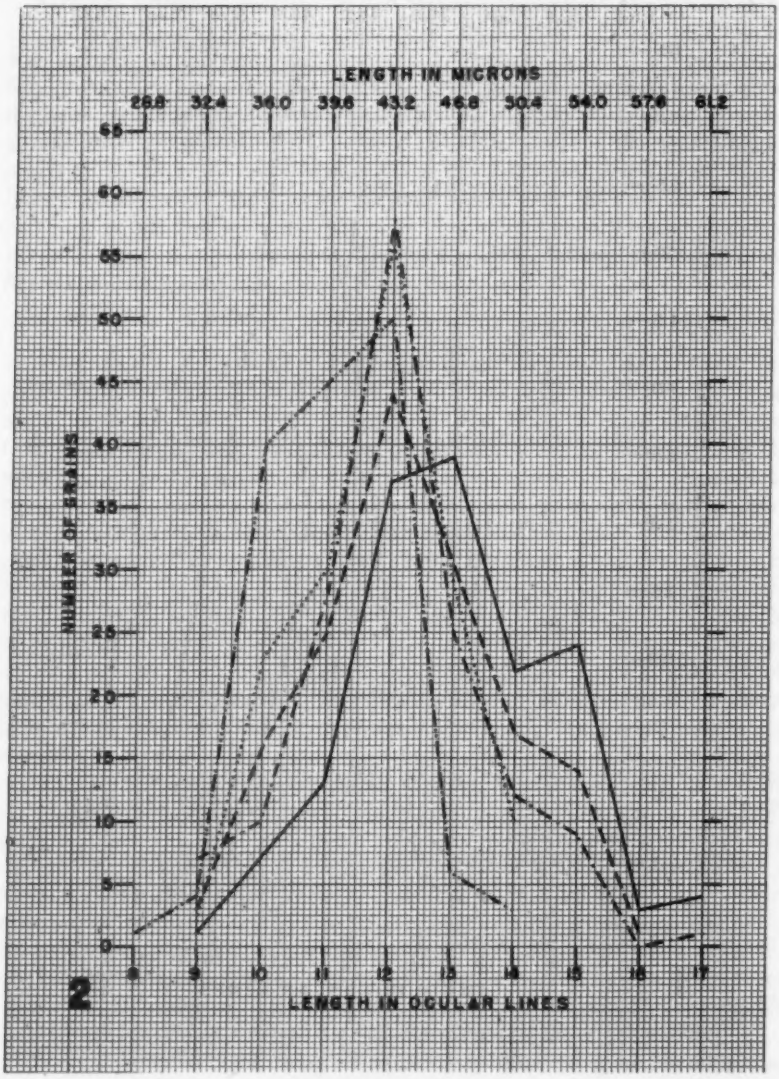

Figure 2. Size-frequency curves of pine pollen extracted from fresh, green moss specimens collected in a jack pine forest.

Figure 3 shows that all three samples analyzed are in remarkable agreement, the "mode" of all being 39.6 microns and the shape of the curves almost identical.

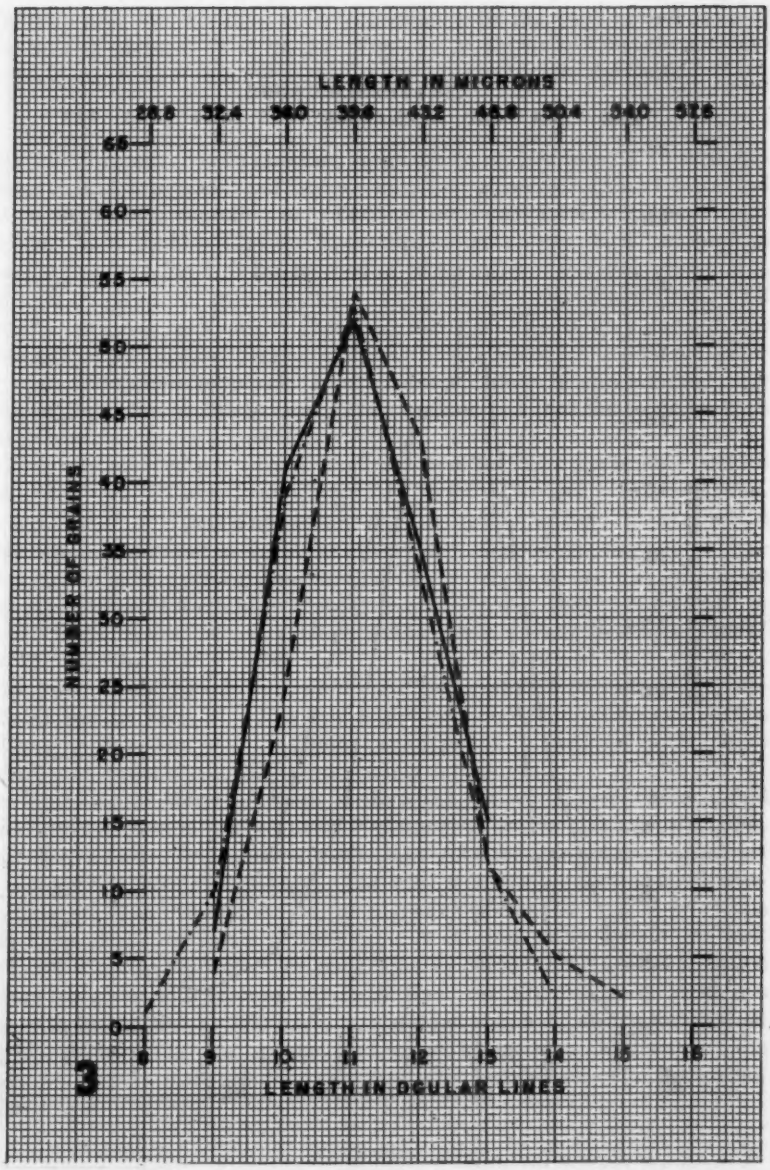

Figure 3. Size-frequency curves of pine pollen extracted from dead moss just below the living green parts of moss tussocks used in Fig. 2.

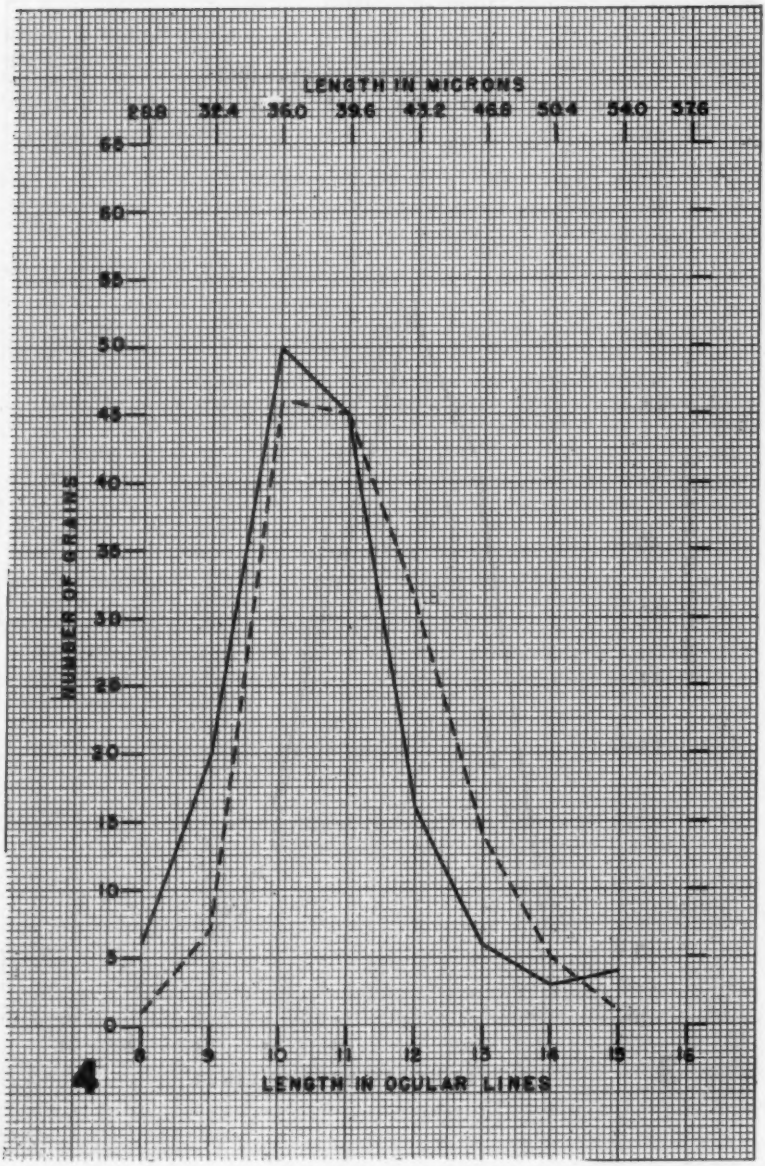

Figure 4. Size-frequency curves of two samples of peat obtained from the upper four or five inches in Jack Pine Bog.

The two peat samples show even less response to the swelling influence of the acetolysis mixture. The "mode" (Fig. 4) is at ten ocular lines (36 microns) but the shape of the curves indicates a slightly larger average size grain.

DISCUSSION

The size-frequency curve obtained from the three herbarium-preserved collections of jack pine pollen and the one collection preserved in formalin showed that an appreciable variation in pollen size may exist from individual to individual. It is possible that the larger size of the pollen which had been in formalin may be related to the method of preservation. For that reason it is best to leave it out of consideration. This is particularly desirable since all previous work has been on dry preserved material. Hence only three of the curves can be used for comparative purposes here. These are too few and show too much divergence to be of value in determination of the size-frequency curve for the pollen of the species. They suggest only that the mode for such a curve would lie above 40 microns.

The construction of size-frequency curves from pollen in living moss yielded curves that very probably closely approach the curve for jack pine as a species. The great majority of pollen grains in such moss are derived from the most recent pollen rain. The shape of the curve is certainly affected by chance contamination by the older, partially fossilized pollen and by the presence of pollen from other pine species of the region whose grains are larger. However, the location of the "mode" is significant. The curves in figure 2 show that this "mode" is at 43.2 microns.

The pollen from the dead moss with a "mode" at 39.6 microns is very appreciably smaller (Fig. 3). The two deeper peat samples yielded grains even smaller than this (Fig. 4). Maximum loss of ability to swell apparently takes several years under the conditions prevailing in this bog.

In the study of pollen of *Pinus serotina* the herbarium-preserved material yielded a curve with a "mode" at 61.2 microns (17 ocular lines) (Buell, 1946). Even when the error due to use of modal classes 3.6 microns apart is considered this represents a distinct shrinkage. The same results are indicated in the present study of *Pinus banksiana*. If, as suggested above, the pollen from the living moss plants represents a fair sample of the last pollen rain in the jack pine forest, then the "mode" of the size-frequency curve for this species as shown in figure 2 is about 43.2 microns. With the fossilized jack pine pollen yielding a curve with its "mode" at 36.0 microns, a distinct shrinkage during fossilization is again evident. The data suggest that the shrinkage is proportional but the true modes must be more accurately approximated before a correction factor can be established.

SUMMARY

1. Size-frequency curves derived from samples of jack pine pollen collected from herbarium specimens and treated by acetolysis indicate that the mode for

the pollen of this species is somewhat greater than 40 microns. That such a species curve has a mode at a point close to 43.2 microns is indicated by size-frequency curves of pollen obtained from young, green parts of moss plants collected in a jack pine forest.

2. In an earlier study *Pinus serotina* pollen was shown to shrink during fossilization. If the curve for pine pollen in the moss, as a fair sample of the last pollen rain, represents a fairly true curve for the species, then fossil jack pine pollen likewise shrinks during fossilization. The data suggest that the shrinkage is proportional for the two species but the true modes must be more accurately approximated before a correction factor can be established.

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PINUS STROBUS SOUTH OF THE UNITED STATES

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One Text Figure

The northern white pine, *Pinus Strobus*, has ordinarily been considered indigenous only in eastern United States and Canada. Coker and Totten (1)

Fig. 1. White pine near Barillas, Guatemala.

say that "it reaches its southern limit in the high mountains of northeastern Georgia". Munns (2) also shows its southern limit as northeastern Alabama and Georgia.

Only recently has it been reported from south of the United States. In 1940, Martinez (3) described a new variety, *Pinus Strobus* var. *chiapensis*, of this species from Chiapas, the southernmost state of Mexico. It differs from the species in having finer leaves often with three resin ducts instead of two. Otherwise the variety appears to be identical with the species.

In his recent comprehensive monograph on Mexican pines, Martinez (4) extends the known distribution of his variety to include Oaxaca and Puebla. Despite his report, I was somewhat surprised early this year to find this pine

(*P. Strobus* var. *chiapensis*) growing naturally in Guatemala. In January small stands of it (Fig. 1) were seen near Barillas in the department of Huehuetenango. It seemed to be restricted to elevations between 4500 and 6000 feet. The associated plants include many genera common to southeastern United States: *Equisetum, Polygala, Rhus, Rubus, Sambucus, Smilax, Thalictrum, Viburnum, Vitis.* Even boxelder (*Acer*) and sweetgum (*Liquidambar*) were noted.

The following month along the steep slopes of the valley of the Río Suchún below Nebáj in the department of El Quiché, Guatemala, this pine was again found. It seemed to be restricted to elevations between 4300 and 5000 feet. It was always scattered among other pine and hardwood species but was more common near the lower elevations, near where the Río Suchún empties into the Río Tzichél. Associated with it in this valley were plants showing varying degrees of affinities with species in southeastern United States: sweetgum (*Liquidambar styraciflua*), wild black cherry (*Prunus serotina* var. *capulín*), sugar maple (*Acer Skutchii*), boxelder (*Acer sp.*), *Chimaphila maculata, Lycopodium complanatum, L. clavatum*, and species of *Adiantum, Botrychium, Carex, Carpinus, Cornus, Equisetum, Fraxinus, Galium, Linum, Myrica, Ostrya, Platanus, Polypodium, Polygala, Pteridium, Quercus, Rubus, Salvia, Sanicula, Ulmus* (*Chaetoptelea*), *Viburnum, Vitis.*

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STUDIES IN THE NUTRITION OF SOME AQUATIC MYXOMYCETES

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Plate 42

The Myxomycetes have long been of interest to both botanists and zoologists because of exhibited affinities with both plants and animals. Although they occupy a more or less intermediate position, it has been generally conceded that the nutrition of members of this group is largely heterotrophic, resembling most that of animals.

Early investigators such as Lister (1867) and de Bary (1887) dealt at first with taxonomic considerations; and only gradually did other aspects of the life history of Myxomycetes come under observation. A review of the literature reveals the rather few nutritional studies which have even up until now been done on these organisms under carefully controlled laboratory conditions. Early recognition of discrepancies in reports of aquatic cultures and instances of pure culture of the organisms prompted a systematic search for such references among the original works of the various investigators.

Myxomycetes were first cultivated by the earliest investigators, such as Cienkowski (1863) and de Bary (1887) on their natural substrata under bell jars in the laboratory. First efforts to grow them on artificial media were made in liquid nutrient solutions, largely because of the general practice of growing related organisms in a similar manner. However, certain authors, like de Bary (1887), had definitely attributed negative hydrotropism or at least aerobic qualities to plasmodia in general; and the full significance of the aquatic habit does not seem to have been recognized until Marshall Ward made his observations in 1884.

Strasburger (1884) grew *Chondrioderma difforme* (now *Didymium difforme* according to Lister) in damp chambers made by placing circlets of cardboard on glass slides, and sowing the spores in a hanging drop of nutrient solution on a sterile cover slip placed on the circle of cardboard. The nutrient solution consisted of decoctions of either cabbage leaf or *Vicia Faba* stems. The life cycle was completed in five days, and fruiting occurred when the plasmodium crept out between the cover slip and the top of the cardboard circle. Characteristic fruiting bodies were formed.

De Bary makes no mention of a possible aquatic nature of plasmodia, merely stating (1887) that "plasmodia, if sufficiently supplied with water, spread...."

Marshall Ward in 1884 records full observations on the life history of a truly aquatic myxomycete, a form of *Didymium difforme*. By the term "aquatic" is meant the passing of the entire life cycle submerged in water; in this case the organism appeared growing on the roots of hyacinths in a nutrient solution. This is the only reference that the writer was able to find of a species capable of passing its entire life cycle in the submerged state.

Cayley (1929), reporting on *Didymium difforme*, makes the rather enigmatic

statement that " . . . increase in size of the older plasmodia is not so marked when they are kept too wet as when the surface of the medium is just sufficiently moist to enable the plasmodium to spread freely. . . ."

Constantineaunu (1906) reports that he obtained completion of the life cycles of several myxomycetes in solutions like Knop's 1%, dextrin 5%, glucose 2.5%, or a mixture of Knop's 1% and dextrin 5%, with a more rapid course of development than on natural substrata.

Both Pinoy (1907) and Skupienski (1920) describe in detail morphological modifications resulting when certain normally aerobic species are grown in very moist habitats. Howard in 1931 makes the statement that a sclerotium from which a plasmodium is forming must have the water removed when the plasmodium has emerged, for "most plasmodia are strongly aerobic and soon die if submerged".

In 1933 Skupienski also casually reports successful cultivation of *Didymium difforme* in a hay infusion, obtaining fruiting in two or three weeks.

In connection with mass production of plasmodia of *Physarum polycephalum*, Camp (1936) cautions that "water in the battery jar must not be of such depth that the gauze or paper is flooded. The plasmodia so far observed appear to be very markedly aerobic, and a substratum flooded with water is not conducive to good growth and activity. . . . However, when the plasmodia can creep across the solid substratum, they almost invariably tend to follow the bridge thus provided rather than creep over the water surface."

Speaking particularly of *Physarella oblonga*, Abbott (1945) states that "plasmodia do poorly on a liquid substrate, no matter how rich in nutrients it may be".

It is interesting and important to note that all of the outstanding contributions made to this aspect of myxomycete culture have been made on *Didymium difforme*, which organism was the subject of investigation for Strasburger, Marshall Ward, Cayley and Constantineaunu.

In view of the fact that these four investigators worked on the same organism, an apparent discrepancy in their reports is brought to the attention of the writer. Marshall Ward (1884) states that he obtained fruiting under water, but that there was conspicuous failure to fruit in "dry air". On the other hand, from the reports of Strasburger (1884), Constantineaunu (1906), and Cayley (1929), fruiting of the same species occurred only in moist air.

The modes of nutrition of the motile stages in the life cycle of a myxomycete, with few exceptions, have only comparatively recently been a subject for planned investigation, previously drawn conclusions having been casually made during research on other aspects of the organisms.

Of the various stages in the life cycle, the macroscopic plasmodium was the first to be studied. Among the first to make observations on the feeding habits of the plasmodium were Cienkowski (1863) and de Bary (1887). The former, reporting on *Didymium libertianum* (then *Physarum album*) in 1863, concludes that "plasmodia, and particularly the myxamoebae, swallow up foreign bodies in the same way as amoebae do." De Bary records absorption of food in the liquid state, and also to some extent the appropriation and digestion of solids.

Strasburger (1884) observed in cultures of *Chondrioderma difforme* (now referred to as *Didymium difforme*) that myxamoebae ingest foreign bodies and bacteria, which he saw in vacuoles in the cells. He was able to detect a subsequent corrosion and disintegration of the bacteria within the vacuoles.

Lister in 1888 gives the first major emphasis to the ingestion and subsequent digestion of solid food materials by myxamoebae, reporting preferential absorption of fungous materials by the plasmodium of *Badhamia utricularis*. He observed the absorption of starch from cooked macerated white potato. In 1890 he actually observed myxamoebae ingest living bacteria by folding pseudopodia over them; he then saw the bacteria in large vacuoles near the nucleus of the myxamoeba, where they gradually became more indistinct to the eye, until nothing was visible but a faint residuum.

On the other hand, Celakovsky, working with *Didymium nigripes* in 1892, reported plasmodia as non-mycophagous, since he observed them as they enveloped spores and hyphae of several phycomycetous molds, and relinquished them unharmed.

Harshberger (1901) infers the presence of several ferments from the digestive action accomplished by the plasmodium of *Fuligo septica*, which used *Pleurotus sapidus* for food.

Pinoy was the first to attempt to analyze the relationship between myxomycetes and bacteria. He concluded (1902) after obtaining plasmodial growth only in test tubes containing bacteria, that bacteria were used directly as food by myxomycetes. In work with *Chondrioderma difforme* and *Didymium effusm*, he obtained "pure mixte cultures" of plasmodia and bacteria, consisting of a growing culture of one species of myxomycete and one species of bacterium.

From his experiments in which he was able to obtain bacteria-free spores that remained viable but did not germinate unless placed with bacteria from another source, Pinoy concluded that germination occurs only in the presence of a bacterium. Some doubt is later cast by Skupienski (1920) on the value of this work.

By use of certain staining methods he was able to observe the various phases of the digestion of bacteria in the interior of vacuoles of myxamoebae of *Dictyostelium mucoroides*, thus substantiating Lister's work. By vacuumatic preservation and drying of the paste formed by myxamoebae and bacteria, Pinoy was able to obtain sufficient quantities of what he concluded to be an intracellular diastase, "acrasidiastase", which produced reactions similar to those of the "amibodiastase" of the protozoologists.

The relationship between the two organisms is interpreted by Pinoy as a parasitic one.

In an article published in 1915, Pinoy not only supplemented work previously done (1907), but clarified several points. His attempts to free the plasmodium of bacteria were made by the use of two agars: milk agar (favorable to the associated bacterium), and flax seed agar (less favorable to the bacterium). *Bacillus fluorescens* and *Bacillus luteus* were the associated bacteria. From spore

sowings of *Didymium nigripes* and *Didymium squamulosum* on milk agar, plasmodia were allowed to develop, and bits of the plasmodia which had crept away from the bacterial growths were transferred to the flax seed agar, where they engulfed and digested any bacteria transferred with them before the bacteria had had the time to reproduce.

Thus, according to his own interpretation, Pinoy obtained pure plasmodia, which lived only a few days, and failed to fruit.

Skupienski in 1920 contests the conclusions arrived at by Pinoy, who claims to have killed accompanying bacteria by heating both bacteria and spores to a temperature of fifty-six degrees Centigrade for two minutes; spores thus treated, according to him, germinate only when a bacterium is added. Pinoy uses these results as a basis for the theory that bacteria are necessary for spore germination. Skupienski, repeating the same experiments, showed that the vitality of the bacterium, *Bacillus fluorescens* Flugge, is greater than that of the spores; and concluded that Pinoy's findings were false. Jahn (1931) and Wilson and Cadman (1928) support Skupienski in this assertion.

In contrast to Pinoy's conception of a parasitic relationship between the two organisms, Skupienski postulates a symbiotic one; according to his interpretation, wherever the bacteria multiply very rapidly, as on potato, development of the myxomycete is hindered. There is, then, a struggle between the developing plasmodium and the bacteria. If the last named are very numerous, they fragment the plasmodium and completely destroy it. He concludes that there is no reason for speaking of parasitism, as did Pinoy. Therefore, he speaks of "symbiosis"; he strengthens this statement by the observation that each myxomycete is accompanied by a different bacterium.

In a work on *Didymium difforme* published in 1928, Skupienski claims to have obtained pure culture. He sowed spores from four-year-old sporangia in which bacteria apparently had died. Weak plasmodia formed which survived for several months, but never fruited. The clarity of the water of condensation and the shining surface of the agar were accepted as proof for the absence of bacteria. When bacteria from other cultures were added, however, the plasmodia soon fruited.

First intensive observations made exclusively on the mode of feeding of swarm cells were those of Gilbert (1928), who, in observations on *Dictydiaethalium plumbeum*, noted that swarm cells during the creeping movement are capable of ingesting solid matter; in addition, soluble material and spores of filamentous fungi may serve as food. The plasmodium apparently exercises no selective action, inert bodies being taken in and thrown off undigested.

Wilson and Cadman (1928), in work on *Reticularia Lycoperdon*, state that "no attempts have been made to obtain pure culture (in this work), and other organisms were sometimes present. . .". In cultures kept for a longer period of time (two or three days), the bacteria became much more abundant, and their increase apparently led to the cessation of development of the plasmodia.

Cayley in 1929 does not attack the problem of the bacterial relationships. However, she mentions casually that "these three species of *Didymium*. . . were

grown on Knop agar... and bacteria were always present in large numbers to serve as food".

Microscopical observations made by Howard and Currie (1931), in connection with material collected from the field, showed the plasmodial atack to be both pathogenic and parasitic.

Howard (1931) reports what several investigators have considered to be an instance of "pure culture". The following is a quotation from the passages in which these references are found: "In contaminated plates, it has repeatedly been observed that the plasmodium moves away from the bacterial colonies, which might be an indication that the latter are not utilized as food. Plasmodia can be freed of bacterial contamination by repeated transfer on acid media".

In another article published in the same year, Howard does not use the term "pure culture", but states that "after several frequent successive transfers on non-nutrient agar, they will be reasonably free from contaminating organisms".

In 1933 Skupienski reports for the first time cultivation of *Didymium nigripes* through the complete life cycle on plain agar made with either tap or distilled water. He explained the erosion of the agar by the plasmodium by saying that a gelatin-dissolving enzyme must be produced. Here he differs with Pinoy, who considers gelatin destruction as purely mechanical, by stating that the enzymatic action is intensified in rate and effect by association of the plasmodium with a foreign organism like *Aspergillus*, for example.

Camp (1936) used rolled oats without an agar base for growing plasmodia of *Physarum polycephalum* in quantity, the pulverized oats being spread directly on the plasmodium, which "creeps up around the oat particles and appears to feed by ingesting and surrounding them directly".

In investigations conducted on over sixty species of Myxomycetes, Smart (1937) found that when swarm cells were grown in nutrient decoctions where particulate food such as bacteria and spores was available, fewer bacteria and spores were ingested than when only particulate foods were available. If favorable dissolved nutrients are present, the swarm cells derive the bulk of their nutriment from the solution.

Although making no claim to pure culture as such, Smart states that "the behavior of the swarm-cells in media completely free from other organisms seemed worthy of investigation.... Therefore spores were washed in exceedingly dilute solutions of mercuric chloride and hexylresorcinol". Such drastic treatment lowered the percentage of germination in some species, but bacteria were reduced to such a degree in the culture that their effect over a period of two weeks may be assumed to have been practically negligible, except in species of *Didymium*".

Making no effort to purify cultures from bacteria, but merely to keep down excessive mold and bacterial growth, Kambly (1939) germinated spores in distilled water, transferring swarm spores to nutrient agar. A thin film of bacteria was always present.

Cohen (1939) was able to grow plasmodia in two-membered culture with *Saccharomyces ellipsoideus* or some other micro-organism, and in pure culture on autoclaved yeast. Attempted pure culture on other media was unsuccessful.

Later, Cohen (1941) concludes that "there is no symbiosis between a bacterium and a plasmodium"; nevertheless he states that "a balance could be obtained in which the plasmodium broke down the starches of the medium into sugars utilizable by the associated micro-organisms, which grew more abundantly and in turn furnished more food for the plasmodium."

The writer has been unable to find in the literature any record of recent and complete research concerning the role of bacteria through the complete ontogeny of a single myxomycete. Previous workers have reported on only some one phase, as, for instance, Gilbert (1928) on the swarm cells and Cohen (1939 and 1941) on the plasmodia.

The possibility of eliminating these associated bacteria and thereby obtaining pure culture of the organisms under study was suggested by a review of the literature, in which only four investigators have been credited with this achievement.

First, Pinoy in 1915 obtained "pure plasmodia" which lived several days but did not fruit. He did this by transferring plasmodial portions which were relatively free from bacteria to new media.

Skupienski in 1920, after repeating Pinoy's experiments, states that it is impossible to separate them (spores and bacteria), and emphasizes the necessity of the presence of the latter, and the symbiotic relationship between the two organisms.

Howard in 1931 reports that "plasmodia can be freed of bacterial contamination by repeated transfers on acid media". However, he makes no claim to pure culture as such.

Cohen (1939) was able to grow plasmodia in pure culture on autoclaved yeast, by first growing them in two-membered cultures with *Saccharomyces ellipsoideus*, and removing the latter by one or two migrations of the plasmodia over non-nutrient agar.

With this background, it was decided to undertake detailed studies of these organisms with especial regard to: first, observations on the life history and nutrition of some myxomycetes which are capable of passing part of the life cycle in water; and second, studies in range of habitat, nutrition and pure culture of the same organisms.

CULTURE METHODS

All of the myxomycetes studied first appeared in the laboratory as plasmodia in aquatic Petri dish cultures of other fungi. The plasmodium of strain I was first seen in a culture of *Achlya caroliniana*, parasitized by *Rozella* sp. # 150, carried on by Dr. J. N. Couch. During the period of seven years from the time it was obtained until 1945, the culture was occasionally allowed to dry; after several months in the dry state, the *Achlya* and the myxomycete could be revived simply by the addition of water and sterilized hemp seed. Plasmodia appeared and disappeared sporadically, growing off the hemp seed and clinging to the bottom of the dish, submerged in water.

Soon after strain I was first obtained, a green alga, subsequently identified

as *Chlorococcum* sp., appeared in uniform growths on the bottom and sides of the dish. The plasmodia used the plant for food.

Strain II first appeared in an aquatic culture of *Allomyces javanicus*, isolated from soil by Miss Elsie Setzer. The cultures of *Allomyces* were allowed to dry from time to time during the period from 1940 to 1945, and were revived for study by adding water and halves of hemp seed to the Petri dishes. The latter served as food material for the *Allomyces*, which survived the desiccation by forming resting bodies.

Plasmodia of strain II were not as vigorous in comparison as those of strain I, the largest being only 1.5 cm. across.

Gross plasmodial transfers were made from the original cultures to new ones by carefully removing the plasmodium with a very fine scalpel, and being certain in transfer to leave the plasmodial mass on the bottom of the dish rather than afloat on the surface. The new Petri dishes were about half filled with "charcoal water", to which sterilized halves of hemp seed had been added, with *Achlya caroliniana* for strain I and *Allomyces javanicus* for strain II. Plasmodia in these cultures were quite small, as were those mentioned in the preceding paragraph, seldom attaining a diameter of more than 2–3 cm. across; and neither fruiting nor visible sclerotial formation ever occurred.

A third strain of myxomycete was obtained, from sawdust material collected by Miss Josephine Stewart, when bits of sterile oak leaves were placed with the sawdust in oak leaf decoction in Petri dishes. It is on the oak leaves that the myxomycete first appeared as a plasmodium, and after about ten days a grayish aethalloid fruiting body appeared on the midrib of one of the leaves. This spot was very near the top of the water, but still submerged.

Spore sowings were made on corn meal agar in Erlenmeyer flasks, after which vigorous plasmodial growth occurred and fruits appeared sixteen days from the time of sowing of the spores.

In an effort to determine the reaction to an abundance of water of a form with a normal plasmodium which lives in air, fruiting bodies of *Fuligo septica* were brought into the laboratory on April 10, 1946. Portions of these aethalia were placed in Petri dishes containing boiled decoctions of leaves of oaks such as *Quercus rubra* and *Quercus stellata*.

Spore germination occurred within 24–36 hours, but no plasmodia were observed until approximately six weeks after the spore sowings had been made. The deep yellow plasmodia characteristic of the species were formed, completely submerged in water, some being as much as 5 cm. across.

These cultures have been maintained for a period of several months; during this time neither noticeable sclerotization nor fruiting has occurred, although some plasmodia crawled out of the nutrient solution, which is the behavior characteristic of the other strains immediately before fruiting.

In October of 1945 the writer began systematic attempts to grow strains I and II in quantity. After comparatively short and quiescent periods, plasmodia which had been transferred by means of a scalpel to new Petri dishes, with *Chlorococcum* sp., began to grow vigorously and fruited after about four weeks. Before

fruiting, the plasmodium moved with the characteristic fan-shaped advancing edge on to the side of the Petri dish, the advancing edge "piled up", and characteristic bodies formed overnight.

The possibility of algae being used as food by myxomycetes was discredited by Lister (1890). However, it has been apparent to the writer during the whole course of these investigations that *Chlorococcum* sp. was used for food. The uniform layer of algae adhering to the bottom of the Petri dish disappeared before the advancing fan-shaped edge of the plasmodium, leaving behind the unassimilable portions of the green plants in hollow reticulations made of diverging and anastomosing tubes through which the plasmodial mass had flowed.

After investigation of media favorable for growth of algae, several were used, best growth occurring in the original "charcoal water"; since there was no characteristic precipitate, as in Knop's, for example, the newly formed plants adhered to the bottom of the dish in a rather uniform distribution instead of to particles of precipitate. Growth on agar was again non-uniform, and plasmodial behavior indicated inability to grow on the agar medium.

It was early noted that the short life cycles of these two myxomycetes and the relative ease with which they could be grown would permit detailed study of nutritional requirements; in an effort to determine their ranges of habitat and to locate the best medium for culture, spore sowings were made on a wide variety of liquid nutrient solutions, solid foods, and on agars to which certain organic or inorganic compounds had been added.

The following culture media are those on which successful growth of myxomycetes was obtained:

1. Oatmeal Broth: To 1 liter of water 50 g. of Quaker Oats were added, heated 15 minutes and autoclaved for 15 minutes at 15 lbs. pressure. (This time and pressure are used in all given preparations of culture media.)
2. Carrot Extract Agar: This was prepared according to Fred and Waksman, 1928.
3. Horse Dung Agar: Add 100 g. of horse dung to 1000 g. water, and boil for 15 minutes. Add 20 g. agar and autoclave.
4. Czapek-Dox Agar: This was prepared according to Fred and Waksman, 1928.
5. Hay Infusion Agar: This was prepared according to a modification of the directions given by Fred and Waksman, 1928.
6. Mannite Agar: The liquid base for this agar is essentially that of Lipman's solution (Waksman, 1927), with an agar base added.
7. P20: A modification of the mannite agar, with levulose instead of mannite.
8. P22: Identical with P20, except that the levulose is omitted from the solution.
9. P23: Identical with P20, except that 30 g. Quaker Rolled Oats were substituted for the levulose indicated in the directions.
10. Corn Meal Agar (1, 2 and 3%): Heat 8 teaspoons corn meal with 1000 cc. H_2O for 10–45 minutes over a steam bath, filter, add water to 1000 cc., and agar according to proportion desired (10 g. for 1%, etc.) and autoclave.

11. Corn Meal Agar (with soil extract): This is identical with corn meal agar. except that a soil extract (prepared according to a modification of Fred and Waksman, 1928) is used as a liquid base instead of plain water.
12. Oatmeal Agar: Prepared according to Howard, 1931.
13. 3% Plain Agar: A mixture of 1000 cc. H_2O and 30 g. agar is autoclaved.
14. Cellulose-Nitrate Agar: Prepared according to Whiffen, 1941.
15. 2% Oatmeal-Corn Meal Agar: 500 cc. each of filtered 2% oatmeal and 2% corn meal solutions were made according to the directions previously given for these agars. This mixture was used as a liquid base.
16. Hemp Seed Agar: 25 g. carefully crushed hemp seed and 1000 cc. H_2O were heated for 30 minutes over a steam bath, 20 g. of agar were added, and the whole was autoclaved.
17. Hemp Seed Filtrate Agar: Materials and proportions were identical with those for hemp seed agar; the mixture was filtered before the agar was added, water was added to 1000 cc. and the whole was autoclaved.
18. Corn Meal Mash Agar and Corn Meal Filtrate Agar: A liquid mixture identical with that for corn meal agar was prepared. To 500 cc. of the filtrate were added 10 g. of agar for the corn meal filtrate agar. To the remainder were added 10 g. of agar for the corn meal mash agar. Both were autoclaved.
19. Sawdust Agar: Heat 50 g. of pine sawdust and 1000 cc. of H_2O over a steam bath for 30 minutes, add 20 g. agar and autoclave.
20. Sawdust Filtrate Agar: Prepare a liquid mixture as for sawdust agar, filter through filter paper, add water to the filtrate to 1000 cc., 20 g. agar, and autoclave.
21. Liver Extract Agar: One-eighth lb. cow liver was crushed in a mortar and the juice thus produced was added to water to make up to 500 cc. 15 g. of agar were added, and the mixture was autoclaved.

OBSERVATIONS

A. *Aquatic Cultures.*

The aquatic nature of the plasmodia which have been under observation is of tremendous interest, from a taxonomic viewpoint as well as in connection with modes of nutrition and anaerobic adaptations.

In both of the first two strains studied, spore germination and plasmodial formation readily occur under water; for the former, only a few hours are required. In culture dishes containing *Chlorococcum* sp., the life cycle has been repeated in one dish as many as five times; spores from the previous fruiting escaping as the sporangial wall breaks and initiating a new life cycle by falling into the water and germinating each time.

A very high percentage of the spores are capable of germination; only rarely is an ungerminated spore seen upon microscopic observation of those sown on a culture dish. However, it was impossible to obtain monospore cultures of either strain I or strain II on 3% corn meal agar, the medium most favorable for spore germination. In strain I germination occurred only when six or more

spores were present. In strain II, only when four or more spores were sown did the spores germinate. If as much as 10 cc. of the water in which myxomycetes have been growing is added to a dish already containing algae in water, and spore sowings are made therein, germination occurs. However, if this water is filtered and autoclaved (15 lb. for 15 min.), the principle which influences germination is destroyed. Wilson and Cadman (1928), Smart (1937) and others have suggested the presence of an autocatalytic agent, effective in spore germination in some species, which is secreted by the spores themselves. Results would seem to indicate that this applied to these two strains, and that the chemical agent, if such be the case, is inactivated by heat.

In connection with *Fuligo septica*, it should be remembered that it is in nature one of the most ubiquitous of the whole group of the Myxomycetes, growing readily and fruiting abundantly. Behavior of the organism in culture indicates an adaptability to water which might be expected in a species otherwise so pliant. Observations indicated that spore germination occurred within 24 hours; it was, then, delayed plasmodial formation which likely accounted for the period of six weeks which elapsed before the plasmodium became visible. When corn meal filtrate or lime was added to the culture dishes, plasmodial growth became more prolific.

B. *Cultures in Broth and on Agar.*

Results of spore sowings on various culture media indicate a wide range of adaptability of these two forms. Spore sowings were made on all of the agars for which directions for preparation were given earlier in this paper.

Growth of strain I occurred on all of those media mentioned, with fruiting on hay infusion, mannite, P20, corn meal (1%, 2% and 3%), corn meal with soil extract, 3% plain, 2% oatmeal-corn meal, hemp seed and sawdust filtrate agars. The time required for fruiting varied from 14 days on P20 and 3% corn meal to 31 on hemp seed agar and 40 on hay infusion agar.

Growth of strain II occurred on the following agars: 3% corn meal, corn meal with soil extract, liver extract, corn meal filtrate, mannite, 2% oatmeal-corn meal, Knop's, P20, P22, sawdust, sawdust filtrate, oatmeal filtrate and oatmeal-corn meal filtrate. Fruiting occurred on all agars tried except liver extract, Knop's, P20, P22 and sawdust agars. Periods elapsing between time of sowing and fruiting varied from 14–15 days on 3% corn meal agar to 29 days on 2% oatmeal-corn meal and sawdust filtrate agars. Most uniform results were obtained on 3% corn meal agar, on which fruiting occurs on about the fourteenth day after sowing of the spores.

Several previous investigators, notably Abbott (1945), have shown definite connection between diminishing food supply and a tendency to fruit; and a sequence of over-rich food supply, increasing acidity of the medium, and subsequent death and failure to fruit. Interesting conclusions can be drawn from a series of cultures obtained in using spores of strain II for spore sowings.

The following culture media were used, named in order from poor to rich organic food supply: plain, mannite, corn meal filtrate, corn meal-oatmeal

filtrate, corn meal, corn meal mash, oatmeal and oatmeal mash agars, all of these being 3% agars.

Growth and fruiting occurred on the first five in this series of eight agars. Plasmodial vigor and size of strands and of the entire plasmodium increased in direct proportion as the amount of available food material increased. On the last three, however (corn meal mash, oatmeal and oatmeal mash agars), there was extremely vigorous growth, with the plasmodial color changing from colorless through yellow and orange to red, but the plasmodium finally piling up and dying without forming fruiting bodies. Similar color changes have been analyzed by Abbott (1945) as indicative of "acid aging", a progressive acidifying of the plasmodium. This change occurred much more noticeably on the agars which were richest in food supply.

These results seem to corroborate those of Abbott obtained on oatmeal agar, and to strengthen the general statements made by Gilbert (1928).

A wide range of plasmodial character has been apparent in connection with all forms of plasmodia studied by the writer. Small size and pale color characterize the plasmodium with little available food supply. On the richer substrata, plasmodia are larger and more vigorous, with thicker branches and advancing edges, and a deeper color. Acquisition of a deeper yellow plasmodial color by those of the first three strains, which were white or grayish in the beginning, is indicative of an abundant and readily available food supply. However, when the plasmodial fragments growing on corn meal agar are cut out and transferred to dishes of plain agar, the plasmodium continues to grow and migrates to the plain agar. It is here more vigorous than on corn meal agar, a moderately deep yellow in color, and fruits in about two weeks. When a gross transfer is made of a bit of an extremely acid plasmodium which is growing on oatmeal agar, to corn meal agar, the plasmodium begins to expand, becomes yellow instead of a deep brick-red color, and fruits in three to four days.

In some cultures on corn meal agar, fruiting of strains I and II occurs directly on the agar; in others, the plasmodium crawls on the side of the dish or flask, sometimes for a distance of five or six cm., before fruiting. A simple, direct relationship between diminishing food supply and a tendency to fruit fails to completely explain this behavior.

On numerous occasions it has been observed that the actual vigor of plasmodial growth has been increased by accidental contamination with a mold such as a species of *Penicillium* or *Mucor*. Skupienski in 1933 stated that the enzymatic action is intensified in rate and effect by association of the plasmodium with a foreign organism like *Aspergillus* sp., for example. He did not venture an explanation.

The fact that growth and fruiting occur on 3% plain agar is in itself an indication that the quantities of basic food materials necessary for these myxomycetes must be small indeed. In the course of these investigations, fruiting occurred on 3% plain agar in 26 days. Skupienski (1933) reported growth and fruiting of *Didymium nigripes* also on plain agar, obtaining fruiting in a shorter time than on the natural substrate. The ability of the organism to grow suc-

cessfully on media so devoid of food supply in quantity poses interesting problems.

In some cultures of strain II, a definite erosion and liquefying of the agar was noticed on the areas of the substratum on which the bacteria were growing. Bacteria found in these areas were always of the same morphological group (bacillus) and occurred in characteristic formations. It is suspected that they are of a type which is capable of liquefying agar. Should this be the case, the plasmodium very probably is able to utilize the product of this chemical decomposition for food. Skupienski in 1933 postulated the production of an agar-dissolving enzyme by the plasmodium, while Pinoy had, as stated earlier in this paper, considered the agar destruction as being purely mechanical.

C. *Attempts to Secure Pure Culture.*

In the course of the spore sowings on these various culture media, it was found to be impossible to obtain pure cultures of the myxomycetes directly from spore sowings. Contaminations of spores of molds and vegetative cells of bacteria, more often the latter, accompanied the spores of the myxomycetes and initiated growth on the Petri plates which interfered with observations. It was concluded that the contaminants accompanied the spores because they appeared in the line of sowing, even after all sterile precautions had been taken. Microscopic examination of the spore masses from the centers of considerable numbers of sporangia verified this, bacteria always being present. It is possible to rid the culture of mold spores without a great deal of difficulty by cutting out blocks of agar containing about 12 or more myxamoebae from recent spore sowings. Care should be taken that no mold hyphae or spores are on the block, which is then transferred to a sterile medium.

Attempts to obtain the organisms in pure culture were begun. Several investigators (Pinoy, 1915; Skupienski, 1920; Watanabe, 1932 and 1933; Howard, 1931; and Cohen, 1939 and 1941) used various methods such as migration and enrichment to purify plasmodia; there is no record of any attempt to carry the organism through the entire life cycle free from bacteria. It was decided to devise techniques by means of which this could be attempted, beginning with mature spores.

Realizing that any organically or inorganically enriched agar base on which spores were sown would also be favorable for the rapid multiplication of accompanying bacteria, the writer used Petri dishes of 3% plain agar.

The myxamoebae were isolated from the accompanying bacteria as follows: Under the binocular dissecting microscope (×25), the wall of a sporangium was carefully removed. The loop of a bacteriological needle was touched to the central portion of the spore mass, and those spores which adhered to it were spread thinly on the 3% agar plate. After a lapse of about thirty hours, spores had germinated, passed through the rotating, comma-shaped stage and had become amoeboid organisms. Some of the motile myxamoebae had crawled away from the initial point of sowing, where bacteria were present in abundance. By use of a needle sharpened to the shape of a micro-chisel, blocks of agar containing the desired numbers of myxamoebae and no bacteria were removed under

the binocular dissecting microscope. The ordinary microscope (×100 and × 215) was used for verifying the absence of bacteria on the agar blocks. These blocks were transferred to sterile Petri dishes, test tubes, and Erlenmeyer flasks of 3% corn meal agar. The cultures maintained can be divided into three types, according to the organism used, all on 3% corn meal agar:

1. Myxamoebae alone.
2. Bacteria alone.
3. Myxamoebae and bacteria combined.

Table I shows the results of these experiments in detail.

It has been stated earlier that those investigators who attempted to obtain pure cultures have met with serious drawbacks and failure in most cases. Practically all of the results of similar research point to some sort of obligate relation-

TABLE I

MYXOMYCETE	BACTERIA	RESULTS
1 amoeba	None	No growth
2 amoebae	None	No growth
4 amoebae	None	No growth
8 amoebae	None	No growth
12 amoebae	None	No growth
16 amoebae	None	No growth
32 amoebae	None	No growth
1 amoeba	Yes	No growth
2 amoebae	Yes	No growth
4 amoebae	Yes	No growth
8 amoebae	Yes	Normal growth and fruiting
12 amoebae	Yes	Normal growth and fruiting
16 amoebae	Yes	Normal growth and fruiting
32 amoebae	Yes	Normal growth and fruiting
None	Yes	Bacterial growth only

ship between the myxomycete and the associated organism, without which the former cannot live.

It is obvious from table I that no growth occurred when the myxamoebae alone were placed on the medium. Any explanation for the failure to produce growth with fewer than eight myxamoebae would probably deal with failure to fuse, either sexually, or vegetatively to produce an increase in plasmodial size. Because the story of sexuality in the Myxomycetes is imperfectly known, the complete answer to this can be obtained only after considerable cytological research has been done on these species. The outstanding fact conclusively shown here is that growth of the organisms occurs only when bacteria are present.

IV. TAXONOMY

Attempts to classify the three strains previously referred to as strains I, II and III resulted in their being placed in the order of the Physarales, family Phy-

saraceae (MacBride and Martin, 1934, and Lister, 1911). Strains I and II strongly resemble one another in morphological characteristics.

A description for strain I agrees most closely with that of *Physarum gyrosum* Rost. (MacBride and Martin, 1934) and *Physarum gyrosum* Rost. Mon. (Lister, 1911). However, sporangial color for this species is given as yellowish-gray or pinkish gray in both of the above-named references, this being at variance with that of the form described. The spore size of 7.5–9.5 μ of strain I is well within that of 7–10 μ given by both references. The hypothallus of the form described is not as strongly developed as is that of *Physarum gyrosum*; however, Lister in his description implies that this strongly developed hypothallus is not always present.

Physarum gyrosum is very close to *Physarum polycephalum* but is not stalked as is the latter. Lister states that it has been considered by some as a sessile variety of *Physarum polycephalum*.

A description for strain II agrees most completely with that of *Physarum nutans* Pers. given by both MacBride and Martin, and Lister.

However, there is a discrepancy in sporangial size among the descriptions. The dimensions for the form investigated by the writer are larger than those of .4–.7 mm. given by both Lister and MacBride, and Martin.

Spore size is given by MacBride and Martin as about 10 μ and by Lister as 8–10 μ, in comparison with that of 5–9 μ for the above-mentioned form.

Lister characterizes the species as a very variable one, and cites several instances of considerable deviation from the description which he gives.

Strain III is obviously an aethaloid member of the Physaraceae. Characteristics of this form are such that it appears to be identical with the *Fuligo cinerea* (Schw.) Morg. given by MacBride and Martin, or the *Fuligo cinerea* Morg. of Lister.

Since this form was brought to fruiting only twice in the laboratory, the above conclusions as to taxonomic position were necessarily drawn from limited quantities of material.

Plasmodial growth obtained with *Fuligo septica* was characteristic of the species.

V. SUMMARY

1. A review of the literature on the Myxomycetes has been made with especial reference to (1) instances of aquatic plasmodia, and (2) instances of pure culture. There is one record (Marshall Ward, 1884) of a Myxomycete, *Didymium difforme*, which passes its entire life cycle submerged in water. Four investigators have obtained what they considered to be plasmodia in pure culture: Pinoy in 1915, Skupienski in 1920, Howard in 1931 and Cohen in 1939.

2. Three strains of Myxomycetes, close to or identical with *Physarum gyrosum*, *Physarum nutans*, and *Fuligo cinerea*, have been grown submerged in water until the fruiting stages begin.

3. Experiments have been conducted which were designed to determine the best culture medium on which completion of the life cycles of these three strains will

occur. Of twenty-six culture media on which some growth was obtained, good growth resulted on several. Best growth, however, occurred on 2% and 3% corn meal agars. Although fruiting occurred on a number of others agars, best fruiting was obtained also on 2% and 3% corn meal agars about fourteen days after spore sowing.

4. Experiments have been conducted for the purpose of obtaining pure cultures directly from spore sowings of two of the strains of Myxomycetes investigated. Successful plasmodial formation and fruiting occurred when a minimum of eight myxamoebae grew with bacteria.

5. From spore sowings, *Fuligo septica* was grown as far as the plasmodial stage, completely submerged in water. However, neither fruiting nor sclerotization ever occurred.

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EXPLANATION OF PLATE 42

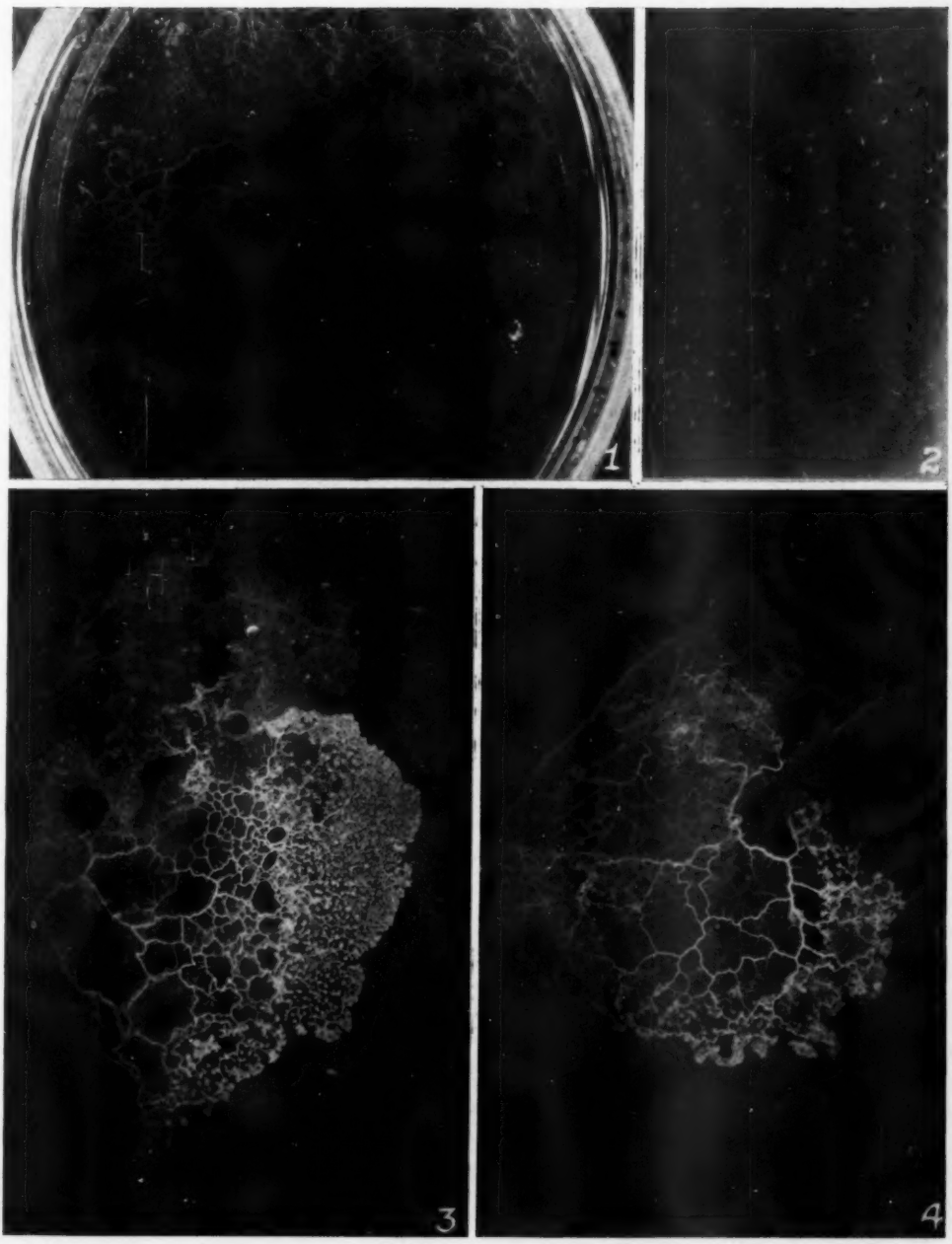
1. Petri dish, with central portion of photograph removed, showing plasmodium of strain I and *Chlorococcum* sp. in water. Note the grayish network on the left which is the only living plasmodium; all other reticulations are hollow tubes left by plasmodia. On the side of the Petri dish, on the extreme right, are sporangia. ×1.5.

2. Sporangia of strain II on surface of 3% corn meal agar in Petri dish. Note stalked sporangia in upper right, and irregularly dehiscing sporangia in center, with black spore mass inside. ×2.5.

3. Plasmodium of strain I growing in Petri dish, with *Chlorococcum* sp. in water. Plasmodium is creeping toward right and feeding on algae, which appear grayish in the photograph. ×1.5.

4. Plasmodium of strain II in water in Petri dish with *Chlorococcum* sp. Plasmodium appears white, while all grayish reticulations are hollow tubes left by plasmodia. Note the contrast between the algal growth, which appears grayish in front of the advancing plasmodium, and darker areas behind the plasmodium, from which the algae have been consumed. ×2.5.

PLATE 42



STRUCTURE OF THE CILIA IN ECTOCARPUS MITCHELLAE AND CODIUM DECORTICATUM

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Three Text Figures

Various workers have reported studies of cilia of the motile cells of a number of Flagellates, Algae and Fungi, and some have attached considerable importance to cilial structure as a systematic criterion. Löffler, in 1889, devised a technique of fixing and staining which enabled him to describe two types of cilia: the tinsel cilium, a thread bearing small secondary cilia along its length; and the whip lash cilium, a thread with a thinner projection at its tip. Fischer (1894) used Löffler's methods and found the same two types of cilia. Petersen (1929) again demonstrated that the tinsel and whip lash projections are actually present, employing the Löffler method with several Flagellates and Algae whose cilial structure had not previously been studied.

Vlk (1938), using the methods of Löffler and Deflandre, demonstrated that the Chrysophyta have two cilia, one a whip lash and the other a tinsel cilium; the Chlorophyta have only whip lash cilia; and the Euglenophyta have only tinsel cilia. Vlk (1939) also showed that the zoospores of certain water molds have one whip lash cilium and one tinsel cilium.

Couch (1941) made more extensive studies of the motile cells of the Phycomycete group, in regard to their structure and to their action. He found three types of ciliation present in the Phycomycetes: posteriorly uniciliated zoospores with a whip lash cilium; anteriorly uniciliated zoospores with a tinsel cilium; and biciliate zoospores with an anterior tinsel cilium and a posterior whip lash cilium.

In all these studies, no report was found of similar work with the ciliated cells of any member of the Phaeophyta group. Vlk (1938) reported an attempt to apply the staining techniques to members of this group, but found that the crystallized salts of the sea water prevented him from getting good results. He concluded that methods used in fresh water forms seemed little suited to sea water inhabitants. Lack of knowledge of types of cilia in the brown algae thus presented a noticeable gap in the study of motile cells, a gap which should be filled if cilial structure is to be of great value in indicating relationships among the various groups of Algae and Fungi. Another group which had been neglected in this type of study was the Siphonales order of the Chlorophyta, the great majority of which are marine.

At the suggestion of Dr. J. N. Couch, a plan was made to try to employ the Löffler staining technique to motile cells of any available marine algae. Permission was obtained to use the facilities of the United States Fisheries Biological Laboratory at Beaufort, N. C., during the summer months. Various sea weeds

were collected, and specimens of *Ectocarpus mitchellae* were found to produce motile cells in quantities great enough to permit the use of the chosen methods. Healthy plants were kept in running sea water, and seemed most active at about seven to eight o'clock in the morning. Small portions of the plant were placed on slides in a few drops of water. On some slides, a sporangium would open after a few minutes and free a swarm of spores. The portion of plant was then removed from the water and the spores were killed in fumes of osmic acid. The

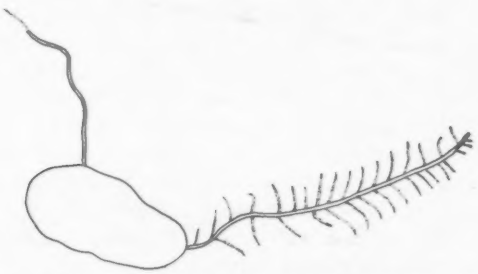

Fig. 1. Spore of *E. mitchellae* stained by Löffler technique. Anterior cilium shows tinsels and posterior cilium terminates in a whip lash. ×1744.

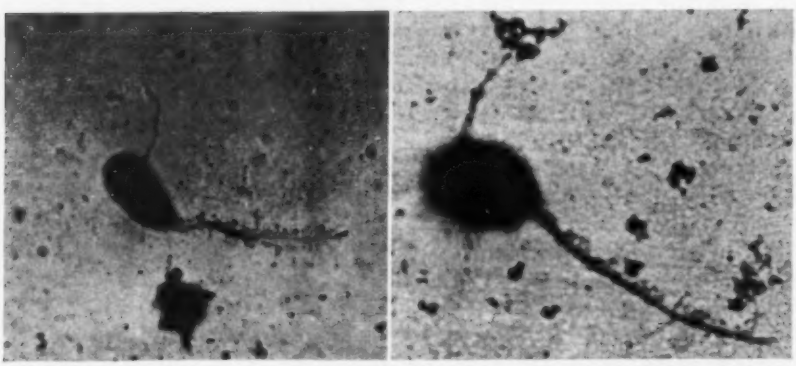

Fig. 2. Photographs of spores of *E. mitchellae* stained by Löffler technique. a. ×1350; b. ×1800.

slide was then dried. Crystals of salt which formed were washed off and the slide was again dried. The staining procedure then followed was according to Couch's modification of the Löffler technique.

Naturally a great many spores were lost in the rinsing process, and large portions of the slides were still blurred by the salt and other impurities. However, several of the slides did have areas which showed the spores distinctly. These, as figures 1 and 2 illustrate, are of a type similar in appearance to spores of the biciliate members of the Phycomycetes, in that they have an anterior tinsel

cilium and a posterior whip lash cilium. My observations of the living spores did not indicate which is the anterior and which is the posterior cilium; however Fritsch (1945) describes the anterior cilium as the longer one, and it is the longer one which has the tinsels, while the shorter one bears a whip lash.

Male gametes of *Codium decorticatum* were obtained with the help of Mr. Louis Williams, who had studied the periodicity of gamete discharge in this species. These gametes were killed and stained by the methods used for the *Ectocarpus* spores. Results show (see figure 3) that the *Codium* gametes have two apically attached cilia, both of which are the whip lash type.

No conclusions are drawn as to any indication of relationship between *Ectocarpus mitchellae* and any other organism which shows similar ciliation. It is somewhat surprising to find that the cilia are of the same type as those of the biciliate Phycomycetes. However, in both cases the cilia are laterally at-

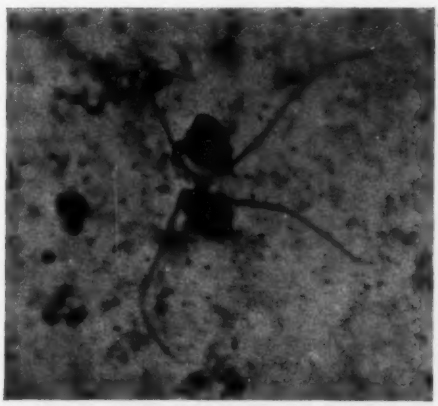

Fig. 3. Photograph of male gametes of *Codium decorticatum* stained by the Löffler technique. ×1800.

tached, one oriented anteriorly and one posteriorly, and this did indicate that there might be a similarity.

In the case of *Codium decorticatum*, the cilia are of the same type as those of other green algae reported. Couch (1941) had suggested that if the biciliate members of the Siphonales were found to have cilia of the same type as those of the biciliate Phycomycetes, there might be reason for reviving the idea of close relationship between these groups. The present studies of *Codium* thus lead to the conclusion that, on the basis of cilial structure, this member of the Siphonales does not show kinship to the Phycomycetes.

The present plan is to continue the work and study cilia of other marine algae, as well as those of several other groups not yet studied by this technique.

I wish to express my appreciation to Dr. Couch, who suggested the project and assisted in interpreting results; to Dr. H. F. Prytherch, director of the

U. S. Fisheries Biological Laboratory at Beaufort; and to Dr. H. L. Blomquist and Mr. Louis Williams of the Duke University Marine Laboratory for their aid in obtaining and identifying material.

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